Energy statistics in New Zealand

Have energy accounts a useful role to play?

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Preface

In 1990 the Centre for Resource Management published an information paper titled *"Natural resource accounting - an overview from a New Zealand perspective with special reference to the Norwegian experience"*. One of the conclusions of that publication was that Norwegian-style energy accounts could be both useful and reasonably easily compiled in this country.

In Norway, the energy resource accounts have been far more widely used than the accounts for other resources like fish, forests and metals. They have also provided an essential information base for devising national strategies for attaining goals for energy-related air pollutants like the sulphur oxides and carbon dioxide.

It would be misguided to work on energy accounts for New Zealand without tackling the wider question of energy statistics. Energy accounts are a subset of energy statistics; they are balance sheets where links between energy data and economic data are formalised.

There are other good reasons for paying some attention to energy statistics at present. A growing concern exists that in this country's hasty retreat from the excesses of the "Think Big" era, we may have thrown the baby out with the bathwater - the bathwater being heavy-handed planning and the baby being information. Increasingly, staff of the Ministry for the Environment and other agencies concerned for the management of New Zealand's natural resources need information about energy.

This project was begun with two major aims. The first was to analyse existing energy statistics as a basis for a comprehensive framework. The second was to test the feasibility of preparing Norwegian-style energy accounts for New Zealand. In addressing the second aim, in particular, an extensive amount of information has been gathered; each chapter concludes with a summary of keypoints that is designed to reduce confusion.

Finally, we would like to add two caveats. Firstly, the energy accounts in this report have been produced for demonstration purposes; they should not be cited in a cavalier fashion. Secondly, the report is aimed at experts, not at the general reader.

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1 Introduction

1.1 Background

This project has evolved from work done at the Centre for Resource Management on natural resource accounting. Readers not familiar with this new field in resource management are advised to read the two reports produced at the Centre on this subject (Wright, 1989; Wright, 1990). However, it is useful to recap a little in order that the rationale behind this publication be understood.

The research has moved through the following stages:

- an investigation into various natural resource accounting methodologies,

- a conclusion that the Norwegian system was of particular relevance to New Zealand,

- an investigation into the Norwegian system,

- an observation that the most useful resource accounts in Norway were the energy accounts,

- a conclusion that natural resource/environmental accounts should be developed in the wider context of natural resource/environmental statistics, and

- a decision to develop energy accounts for New Zealand in the context of energy statistics.

1.2 Natural resource accounting

The great interest in the field of natural resource accounting (and/or environmental accounting) stems from dissatisfaction with the treatment of resource depletion and pollution in the System of National Accounts (SNA). One fundamental problem is the emphasis on flows (income and expenditure) and the relative neglect of stocks (wealth) in the application of the SNA. Conventional yardsticks of economic growth like Gross Domestic Product (GDP), by which we measure our economic welfare, are found to be inadequate under close inspection.

> *"A country could exhaust its mineral resources, cut down its forests, erode its soils, pollute its aquifers, and hunt its wildlife and fisheries to extinction, but measured income would rise steadily as these assets disappeared"* (Repetto, 1988, p.2).

The natural resource (or environmental) accountant seeks to develop ways of measuring interactions between the economy and the environment and to represent these interactions in "accounts" of various kinds. These accounts vary from "greening" of the SNA at one extreme to preparing physical balances of stocks and flows at the other. Whichever is the case, the basic purpose is to provide some of the important information that is absent in conventional accounting.

1.3 The Norwegian system of natural resource accounting

An in-depth study of the Norwegian natural resource accounting (NRA) system seemed most useful for New Zealand for a variety of reasons. New Zealand and Norway are similar countries in a number of relevant aspects and Norway has invested more in its NRA system than any other country and over a longer period of time. It makes sense for New Zealand to "jump up" Norway's learning curve; such a jump was a major objective in the work of Wright (1990).

The Norwegian NRA system is often described, rather disparagingly, as being a "physical" as opposed to a "monetary" system. However, it is more accurately denoted a "mixed" system since, although the accounts are in physical units, specific links are made, both with sectors of the economy and with resource valuations. Thus the central objective of NRA, the formalising of links between the environment and the economy, is realised, to some extent at least.

A detailed description of the Norwegian system can be found in Wright (1990); the structure of the energy accounts are described in this publication in Chapter 5 prior to attempting Norwegian-style energy accounts for this country.

1.4 Natural resource accounts as a subset of environmental information

The precursor to any kind of resource or environmental account is a data base of relevant physical information. There is no clear division between environmental monitoring and environmental accounting. A set of natural resource accounts or a state of the environment report are both products of a set of environmental statistics.

It would seem shortsighted not to set resource accounts in their place in an environmental statistics framework. Resource accounts are one way of presenting information; this information may be usefully presented in other forms. Also, the construction of a framework for environmental statistics should be influenced by the concepts of resource accounting; for example, the production of pollutants and the consumption of electricity should be broken down by economic sector. It is no accident that, in the Central Bureau of Statistics in Oslo, the Resource Accounting Unit and the Environmental Statistics Unit work closely together.

In this project, an attempt is made to develop energy accounts in New Zealand within the wider context of an analysis of energy statistics. The body of the publication falls into two parts. The next three chapters comprise an overview of energy statistics in New Zealand leading to an identification of imbalances, omissions and inaccessibility in current energy data. The remainder of the publication comprises the attempt to prepare energy accounts for New Zealand.

1.5 Why energy?

There are two main reasons for the decision to examine the information available on this particular resource.

Firstly, the energy accounts are unquestionably the most successful of the Norwegian resource accounts. Their use was instrumental in curbing over-investment in hydropower in that country. They are currently being used in a macroeconomic approach to energy conservation and have provided the basis for environmental "emissions accounts" for energy-related pollutants.

Secondly, energy is once again becoming a high profile natural resource in this country. Many energy experts are concerned about the tremendous loss of energy data that has occurred in the last six years. An overview of energy supply and demand is essential for dealing with many environmental issues such as the design of effective strategies for meeting energy-related pollutant targets.

Summary of Chapter 1

Natural resource accounts formalise the links between economy and environment on a macro level.

The Norwegians have invested more time and effort in natural resource accounting than any other country; for this reason, and because of some similarities between the two countries, it makes sense for New Zealand to "jump up" Norway's learning curve.

The most useful accounts in Norway are the energy accounts.

Natural resource accounts should be developed within the wider context of natural resource/environmental statistics.

The aim of this publication is to examine the feasibility of Norwegian-style energy accounting in New Zealand within the wider context of energy statistics.

2 Why should energy data be publicly available?

2.1 Does energy deserve special treatment?

Before devising a framework for energy statistics, or before compiling energy accounts, it is necessary to examine the general reasons why energy data should be collected and made publicly available.

Arguing for energy statistics to be freely available is tantamount to claiming that the energy sector deserves special treatment. Energy is given a chapter of its own in the *"New Zealand yearbook"*. Why is this insufficient? Exploring the reasons for energy statistics must involve some consideration of the special nature of energy.

The reform of the energy sector has been (and is) based on the assertion that there is, in fact, nothing special about energy. Advice from Treasury officials to the Minister of Finance in 1988 reads:

> *"We consider that although energy is both essential and strategically important it is not unique in these attributes. For example water, steel and plastic are all essential commodities and like energy utilised both as inputs and in their own right. Similarly butter access to the EEC and other trade issues are of great strategic importance"* (The Treasury, 1988).

It is not difficult to mount counter-arguments to this view. Fuels are indeed commodities but energy is something rather more fundamental. Although it takes energy to produce butter, it does not take butter to produce energy. Energy is a ubiquitous input. Infinite substitutability is one of the basic tenets of neoclassical economics; adherents of this branch of economics should note that even technological optimists like Goeller and Weinberg (1976) conclude everything can be substituted for, provided that there is unlimited energy. There will always be plenty of steel and fresh water, provided there is plenty of energy to reduce iron ore and desalinate seawater.

The purpose of the Treasury paper cited above was to persuade the Minister of Finance that the Ministry of Energy should be disestablished. Whether a Ministry of Energy should exist as a separate entity and engage in energy planning is a different issue from the issue of providing public information about energy. The two issues have not been separated in the past. For instance, in the 1983 review of energy and mining statistics, the need for energy statistics is closely linked with the need for energy planning, which in turn, is based on an anticipated shift away from imported oil (Department of Statistics, 1983).

Even now it is difficult to separate the public information issue from the wider question of the degree of intervention in the energy sector. One current view is that publicly available information is *per se* a bad thing because information brings with it the temptation to intervene. Opponents of free availablility of information might consider whether open sharing of information might not sometimes lead to acceptability of private sector energy projects by increasing public understanding. Secrecy is likely to engender mild paranoia.

Certainly, other countries have managed to separate the information issue from the intervention issue. Countries where energy has always been supplied by the private sector, do make energy data generally available. The United States, for instance, publishes a *"Monthly energy review"* (Energy Information Administration, 1990). So does the highly capitalist country of South Korea.

In this publication, we are not entering the current debates about whether the Energy and Resources Division of the Ministry of Commerce should engage in energy forecasting or who should own the electricity transmission grid or any other current energy intervention issue. Rather, we are interested in identifying general areas of legitimate public interest in energy where energy statistics will lead to a wider and better debate. Four such general areas are discussed in the next four sections.

2.2 Monitoring

It is not difficult to find calls for Government to "keep an eye on" the energy sector.

> *"Despite these changes, the energy sector has special characteristics which have not altered. These include its strong interaction with resource development, its substantial technological basis, the uncompetitive nature of many energy markets and the long time scales of energy developments. These factors point to the desirability of maintaining, within Government, an overview of energy sector activities which is independent of the planning and operation of the state owned enterprises"* (Ministry of Energy, 1988, p.7).

Some might claim that the above arguments carry little weight when made by the remnant of the Ministry of Energy, that is, the Energy and Resources Division of the Ministry of Commerce. Similarly, the first recommendation (for monitoring) made by the team from the International Energy Agency (IEA), who conducted an in-depth review of energy policy in New Zealand in 1990, might be seen as the voice of vested interests.

"The Government of New Zealand should: (inter alia) continue to monitor the impacts of the substantial changes already made in the energy sector and, in planning further changes, ensure that objectives such as greater energy security and an improved environment are taken into account along with the aims of improved economic efficiency and development" (IEA, 1990, p.271).

It would take a committed ideologue to argue that there is no case for monitoring the energy sector. How else is Government to know the effects of its policies? How will it be known whether non-intervention has resulted in the most efficient allocation of resources or not? The Electrical Supply Association is to be commended on providing clear reasons for publishing their *"Electricity supply industry statistics"*.

"As regulations are rolled back, the Government requires statistics to evaluate the impact of its policies. The new emphasis on 'transparency' also requires that the public has a ready access to basic information" (Electricity Supply Association, 1990, p.5).

The monitoring of past reforms is essential in evaluating proposed reforms. One current issue in the energy sector is the ownership of the electricity grid. Another is the proposed breakup of Electricorp into several separate generating authorities. Good decisions on these and other energy issues are unlikely if the decision makers are too reliant on information supplied from one source. Holding a monopoly on information is the standard technique for capturing decision makers.

Further, in spite of all the deregulation, energy continues to be a subsidised sector. Under the last Government, $340 million were transferred from general revenue to Electricorp for the Clyde dam. Tax incentives for petroleum exploration is one of the present Government's pre-election promises. The receivers of such subsidies are surely bound to provide taxpayers, the source of this money, with information that will enable the quality of such investments to be evaluated.

On the other hand, taxpayers are suspicious of energy taxes being used to "milk" inelastic demand for general revenue.

2.3 Market failure

One of the major reasons for the failure of markets is the concentration of market power and energy markets are highly concentrated. For a number of reasons they are natural monopolies; establishing and maintaining a competitive supply side is virtually impossible. The electricity and natural gas industries are monopolistic, both at the production and distribution levels; the petroleum industry is oligopolistic. Market concentration occurs to a lesser extent on the demand side where a large energy buyer like an aluminium smelting company can negotiate a low price.

Consequently, consumers tend to distrust energy suppliers and public interest in the details of energy supply is high. This distrust cannot be allayed by the reporting of prices and profits. If Electricorp, for instance, makes an unwise investment, losses will be borne by the captive consumers; profits can be shifted up or down with price changes. Because the wisdom of investments cannot be evaluated, there is little accountability.

Because private (or quasi-private) ownership of natural monopolies like electricity and railways is relatively new in this country, we do not have the ingrained suspicion and regulatory institutions of some other countries. The Public Utilities Commission in the United States, for instance, has far greater powers than our Commerce Commission.

There are reasons other than market power why energy markets might be "inefficient". In his argument for "indicative energy planning", Read asserts that because of the substitutability of one fuel for another, the energy sector in New Zealand must be treated as a whole for optimal efficiency.

> *"... in the British energy planning procedure with which I was involved, I observed that the individual industries demand forecasts, when added up, invariably totalled more than the forecast growth of energy demand as a whole. The provision of excess capacity, based on such optimistic forecasts, is precisely what economic theory would predict as the outcome of a struggle for market share in an imperfectly competitive market"* (Read, 1990, p.68).

2.4 Long term and strategic concerns

A variety of concerns about energy could be classed as "long term" or "strategic". It is a trusim that Government is expected to have a longer time horizon than the market place. The most obvious of these long term concerns is our dependence on oil with its implications for national security and the resilience of the economy. The Treasury paper cited earlier states:

> *"We consider that the energy policy which maximises welfare will be that which allows the true cost of energy to be reflected most accurately in its price"* (The Treasury, 1988).

It would be interesting to calculate the "true" price the West is paying for oil were it to incorporate even part of the cost of the Gulf War. The political implications of energy supply cannot be ignored.

> *"... Think Big's emphasis on energy supply seems to have created a sense of security that was not felt in other OECD countries, where the political instability of the Middle East encouraged consumers to work towards reducing their overall energy dependence"* (Bertram, 1990a, p.4).

The IEA review team, in expressing concern about New Zealand's rapidly rising energy intensity, suggested that policies will be required *"to complement short-term measures to meet energy security challenges in the longer term"* (IEA, 1990, p.270).

Concerns about long term security of energy supply lead to that puzzlingly controversial word, "sustainability". Currently, the proposed Resource Management Act has, as its purpose, *"to promote the sustainable management of natural and physical resources"*. Whether this goal passes into law as the prime purpose of the new Act remains to be seen; however, it is clear that our current mix of energy sources is not sustainable into the long term. Some kind of transition to a different mix is inevitable and the nature of that mix is very much in the public interest.

One major feature of the energy sector that it would seem unwise to try to sustain is the growth in the energy intensity of the economy. Recently, attention has been focused on the rather aberrant nature of the relationship between GDP and energy consumption in this country. New Zealand is one of the few OECD countries to use an increasing amount of energy to generate a dollar of GDP and the energy/GDP ratio is *"rising at a rate faster than for any other IEA country"* (IEA, 1990, p.270). While there are difficulties with this type of analysis, there is a strong indication that New Zealand is overinvesting in energy supply.

2.5 Externalities

Finally, there is the question of externalities, those costs and benefits that are not internal to energy markets.[1] Externalities are often classed into two groups - social and environmental. There are some major social (and cultural) issues associated with the restructuring of the energy sector; New Zealanders have been reluctant to abandon the notion of energy as social welfare, (Royal Commission on Social Policy, 1988, p.255). Thus, for instance, the monitoring of energy prices paid by different groups will continue to be of interest to the public; the annual reports of energy companies record only average prices.

However, it is the environmental externalities of the energy sector that are of interest to the Ministry for the Environment and many others. The public concern about energy that has increasingly grown throughout the last decade has been motivated less by scarcity (and price) and more by the environmental impacts of energy production and use. Many of the greatest environmental concerns are energy-related. Several major nature conservation groups have begun to recognise the central role of energy and added the promotion of energy conservation to their more traditional activities.

Because so many environmental costs are associated (directly or indirectly) with energy production and consumption, tracing energy flows through the economy can be a convenient means of analysing environmental problems. The most obvious example is the problem of designing a strategy for achieving the Government's carbon dioxide reduction target. Without detailed information on energy supply and demand, the Ministry for the Environment cannot advise Government on means for achieving this goal. Later in this publication it is shown that energy accounts provide some of the information required for this particular task.

Another "green" concern is the rapidly increasing energy consumption in this country. More energy consumed almost always means an increase in environmental costs and one concern with the move toward privatisation is that aggressive marketing accelerates growth in energy consumption.

The energy data requirements for analysis of environmental issues overlap with those required for monitoring and other policy development. It is necessary to have information on internalities in order to consider how externalities might be internalised.

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1 Long term and strategic concerns, which have been discussed in the last section, could also be classified as externalities.

2.6 In conclusion

Why should the public have access to energy information? The essential reason is that the public's employees, the Government, must be held accountable for the way the country's natural resources are produced and used.

Energy is an input to every economic activity and is being used increasingly to extend the yields or availability of other natural resources. For example, nitrogen fertilisers (made from natural gas) are used to increase agricultural yields, fishing is moving further offshore, wood products are substituted for by aluminium and plastics, and metals are recovered from ever lower grade ores. An essential feature of fossil fuel mining is that it also is becoming more energy-intensive, so that the net energy recovered declines as high-grade reserves are depleted.

It is useful to draw a parallel between agriculture and energy. The agricultural sector is almost exclusively in private hands. Yet there is a strong public agency that gathers very detailed information on many aspects of agricultural activity. This information is used for monitoring, for studying prospects for the future and setting priorities for various agricultural activities, including research and development. Both agriculture and energy are very important strategically to New Zealand's development prospects.

Summary of Chapter 2

The restructuring of the energy sector in New Zealand rests on the belief that energy is simply a commodity. We disagree.

Even when energy supply industries are privately owned there are important reasons why information on energy should be accessible to the public.

Monitoring of the energy sector is vital. At the very least, the impact of policies must be assessed. Government continues to use general taxes to subsidise the energy sector.

Energy markets have a strong tendency to become concentrated.

Energy is strategically important in many ways. For instance, our dependence on oil imports from politically unstable countries cannot be ignored.

Many environmental costs are associated directly and indirectly with energy production and consumption. Attempts to internalise these costs to the market will never be completely successful.

3 Energy information in New Zealand

3.1 Introduction

The design of a framework for energy statistics must be influenced by the availability of data; it is pointless advocating the inclusion of data that would be prohibitively expensive or impossible to collect. It is commonly believed that energy data have become increasingly inaccessible to the public over the last few years due to the reform of the energy sector.

In the heyday of energy as the fashionable resource, that is, roughly the decade from 1974 to 1984, the annual Energy Plans were a widely read source of energy information - both data and policy[1]. The demise of the Energy Plans appears to symbolise the decreased availability of energy data that accompanied the reform of the energy sector. The first Energy Plan was published in 1980 and each successive Plan was longer (and, presumably, contained more information). The last Energy Plan was published in 1985 and was nearly twice as long as the first. In 1986, there was no Energy Plan, but a somewhat shorter document appeared titled *"Energy issues 1986"*. In 1987, no overview of the energy sector was published. In 1988, a glossy report titled simply *"Energy 88"* appeared; this document is even shorter than the 1980 Plan, contains rather more discussion than data and appears to have been virtually unread.

In this chapter, the availability of energy data in this country is examined; part of this exercise involves testing the perception that there has been an enormous loss of accessible data.

3.2 Recent history of the energy sector

Data availability is, of course, intimately connected with public and political philosophy and institutions and, therefore, it is appropriate to review the recent reforms of the energy sector.

The huge interest in energy during the late seventies and early eighties was, in New Zealand as elsewhere, mainly based on the "oil shocks" of the seventies. However, in this country, the energy crisis was seen by many as an opportunity rather than a disaster. Certainly, a vastly increased price of oil made transport much more expensive, but electricity was relatively immune. New Zealand was touted as an

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[1] In writing about the demise of energy planning and the Ministry of Energy, we are not arguing here that these reforms were "bad"; rather, our concern is simply with the effect on publicly accessible energy statistics.

energy-rich country and exploitation of our energy resources was advocated as the way to future prosperity.

Others saw it differently and energy, already on the environmentalists' agenda because of a brief flirtation with nuclear power and the Lake Manapouri controversy, became a "hot" topic in the media so it seemed nearly everyone was debating the merits of energy projects like the Clyde high dam, the Motunui synthetic petrol plant and the Marsden oil refinery expansion.

Underlying all this was the philosophy that the provision of energy was an issue of national security and of development and, therefore, the business of government. A large, powerful Ministry of Energy forecast demand and planned supply where government investment was directly involved. Members of the public read discussion documents, wrote submissions, and attended energy conferences. Under a highly ranked Minister of Energy, a great deal of energy research was funded and, as part of this activity, various data bases were established. The New Zealand Energy and Research Development Committee (NZERDC) and the Liquid Fuels Trust Board (LFTB) were the two main conduits for research funds.

In just a few years the energy sector in New Zealand was radically changed. Although similar forces drove change elsewhere in the world; the extent (and, probably, the speed) of the reforms has been greater in this country than in most.

World concern about energy fell as the price of oil fell. However, in New Zealand a new concern rose; a major contributor to the mounting public debt was government investment in large energy projects. A new philosophy became dominant in which energy is viewed as a commodity to be traded and not as a strategic resource in need of special public policies and management. The provision of joules, like that of any other commodity, is seen as the business of the private sector.

The application of this new view of energy saw the Ministry of Energy broken up, with most of the trading functions becoming the responsibility of profit-oriented state-owned enterprises (SOEs). Both state-owned enterprises and private energy companies are reluctant to part with data on the grounds of commercial sensitivity. A common complaint is that this is a reason used unnecessarily for not divulging information and that the energy SOEs are far more "uncooperative" than the private energy companies (Ministry of Energy, 1988, p.34).

A much reduced Ministry of Energy was finally absorbed into the Ministry of Commerce as the Energy and Resources Division in 1989. Public interest energy research all but ceased with the disestablishment of the NZERDC and the LFTB. The Department of Statistics began charging for information including energy-related data.

3.3 Sources of energy data

As discussed above the most accessible sources of energy data - the Energy Plans - have ceased to exist. The Energy Plans were multi-purpose; they contained discussions of various aspects of energy policy, descriptions of research in progress and so on. But the major part comprised a relatively short section on energy demand followed by a relatively long section on energy supply. The demand section contained historic and projected consumptions for major sectors (household, transport, industrial and commercial, major projects) by fuel type. The supply section comprised an overall survey of energy resources with world oil price forecasts followed by estimates of indigenous energy reserves. Then the plans for each sector - oil and gas, electricity, coal, etc. were presented.

The Energy Plans did provide an overview of the whole energy sector. Their major purpose was, of course, planning and only data superficially pertinent to that purpose was presented. Further detail was given in a range of background documents like the reports of the Electricity Sector Forecasting Committee.

Another Ministry of Energy data source was the monthly *"Energy data file"*. Supply side flows of different fuels comprise most of the content. The *"Energy data file"* was begun in 1981, is still updated monthly and is now published every six months by the Ministry of Commerce.

A long time series that has survived three restructurings is the electricity statistics published first in 1937 by the New Zealand Hydro Department, then the New Zealand Electricity Department, then the Electricity Division of the Ministry of Energy and now by the Ministry of Commerce (Ministry of Commerce, 1991). These reports contain data on electricity production and on sales broken down by supply authority. A new compilation of electricity data has been published by the Electricity Supply Association (ESANZ, 1990). These two collections overlap to a considerable extent.

The Department of Statistics continues to collect energy supply and demand data from various surveys and exchanges information with the Ministry of Commerce. However, the trend seems to be towards less rather than more energy information; for instance, the 1992 economy-wide survey is likely to produce less energy information than the 1987 survey (pers. comm., G. Mead, Department of Statistics, 1991). However, most of the energy statistics contained in the *"Monthly abstract of statistics"* have been continued in its glossier successor, *"Key statistics"* (Department of Statistics, 1957-88 and 1989-91).

Besides the demise of the Energy Plans, the data loss most noticed by energy analysts has been the result of axing the NZERDC and the LFTB. Numerous projects funded by these organizations resulted in a variety of data bases. Not all of them ended up in published form, for example, the massive data base on the characteristics of the vehicle fleet remained internal to the LFTB. However, most of these data bases were *ad hoc* and contained data for only one year or for one specific purpose. One data base that has survived restructuring, although there are no guarantees, is the series of energy input-output tables used as a base for some of the energy accounts in this publication.

In the period of intense interest in energy, various other institutions also funded energy research and generated data, although again time series were rare. One such institution was the Building Research Association of New Zealand (BRANZ) which published a large number of reports on energy use in buildings.

One new source of information is the annual reports of the new energy SOEs. Electricorp have provided more statistical data in their later annual reports than in their earlier annual reports. It is worth noting that in the asset valuation preceding the establishment of the SOEs, historical information was given no value and essentially is a gift to these monopolies.

It is possible that the "richest" sources of SOE information will now be in Planning Tribunal evidence. Commercial sensitivity can be readily jettisoned in a battle such as that recently fought for the waters of the Wanganui river. One set of Electricorp's evidence contains information on demand forecasts, reserve capacity and the costs of new power plants, all of which are not normally released (K. Turner, 1990). However, information released in this way by its monopoly owner is not independently verifiable and, of course, only that favourable to the owner's case need be presented.[2]

The trend toward less information that has followed restructuring of the energy sector does appear to have been partly reversed within the Energy and Resources Division of the Ministry of Commerce. A new Resources Information Unit is actively involved in producing estimates of energy resources. Summaries of data on coal and hydro resources have been published with petroleum and geothermal resources in preparation.

It is difficult to speculate about the changes likely in the availability of energy data. Two very different political philosophies could push energy policy (and data) in different directions. On the one hand, a possible return to a policy of self-sufficiency could mean a return to public energy forecasting and even planning with a concomitant requirement for data; on the other, a move further toward privatisation and a reduction of public sector expenditure could make energy data increasingly scarce.

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[2] There is nothing new about this; enquiries of various kinds often result in the release of huge amounts of information, for example, the Royal Commission on Nuclear Power in the seventies. Electricorp's predecessor, the New Zealand Electricity Division, was not always forthcoming with information.

3.4 Some concerns about energy data

In 1983, the Department of Statistics conducted a major review of energy and mining statistics. The resulting report contains 26 recommendations, few of which have been implemented.

The review committee was concerned about the lack of an overall framework for energy statistics and recommended that the energy balance (or matrix) proposed by the United Nations Statistical Office be used as a starting point. This has been done; the Energy Matrix now appears as part of the Energy Data File. However, the 1983 review committee recommended that demand in the Energy Matrix be broken down by the standard economic sectors; this has not occurred. The *"Guide to sources of data on national energy consumption"* (Brown Copeland, 1984) shows how difficult it is to find demand side data.

The 1983 Review Committee was also concerned about the dissemination of energy statistics and recommended the production of an annual volume of energy and mining statistics. During the review, the NZERDC were strong advocates of a centrally accessible record of information. Energy data clearly became an issue of increasing importance to the NZERDC; towards the end of their existence they launched a project titled "Towards an energy information base".

As part of this exercise, the NZERDC commissioned the publication of a booklet titled *"Energy data and conversion factors: a New Zealand handbook"* (Baines, 1984). Prior to this publication, officials in the Ministry of Energy used a collection of second and third generation photocopied sheets, heavily annotated with scribbled additions and adjustments and no records of sources. Four out of the six Energy Plans had been produced on this basis.

Evidence that reform of the energy sector has led to an excessive loss of energy data has come from the International Energy Agency. In the report of the IEA review team in 1990, concern is expressed about monitoring to the extent of advocating energy forecasting - *"up-to-date projections of future supplies and demands to support the development of the government's energy policies"* (IEA, 1990, p.271). As a member country of the IEA, New Zealand must prepare regular returns of statistics and has had some difficulty complying with this.

> *"The lack of information is also affecting New Zealand's relationship with the International Energy Agency... The IEA is concerned that it is no longer receiving this information, which is generally available from countries which have always been dominated by the private sector"* (Ministry of Energy, 1988, p.34).

Within New Zealand, one frequently heard concern is about the cost of energy information. The application of the "user pays" philosophy to energy statistics has not been popular among those used to free energy information. For instance, the Energy Data File used to appear monthly as a humble set of photocopied sheets; the new glossy version appears every six months and costs $95 per year. Theoretically, this should not block public access provided copies are stocked by libraries; in practice, energy data can be hard to find in libraries since such "grey literature" is notoriously difficult to catalogue.

One researcher has argued that government publications should be sold at the marginal cost of duplication (Bruhns, pp.33-34). However, the real effects of reform on data availability are not felt in the purchase of publications. The real change has occurred where research is commissioned by SOEs and the results are only available to those who can pay consultants' fees.[3]

Many energy researchers lament the loss of data under reform but perhaps forget that the situation was far from ideal prior to reform. Historical data are still available. The public no longer knows what is planned for the future, but such knowledge in the past did not often result in real debate and participation.

However, there is little current commitment to the production of high quality energy data. Apart from the electricity statistics, the dislocations and discontinuities remain.

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[3] A personal anecdote may help illustrate the change. Recently, one of us rang the author of an NZERDC report to enquire whether he had updated some tables in it. The tables had been updated - the data did exist - but the job had been done for a consultant working for one of the SOEs. In response to a request for permission to use the updated data, the consultant said that we were free to use it, but could not *"cite or publish it"*.

Summary of Chapter 3

The energy sector has been radically restructured in the last five years. Sources of energy data that have been lost during restructuring include various Ministry of Energy publications, especially the Energy Plans. With the demise of the NZERDC and the LFTB, publicly accessible energy research (including much data gathering and analysis) has virtually ceased.

Some series of energy statistics have been continued, most notably the Energy Data File and the electricity statistics.

Some useful overviews of energy resources are being produced by the Ministry of Commerce.

A major review of energy and mining statistics was done in 1983. Most of their recommendations have not been implemented.

There is little commitment to the ongoing production of accessible high quality energy data in New Zealand.

4 What is wrong with energy data?

4.1 Introduction

This chapter is a critique of energy information in this country. Such a task should ideally be done by a group pooling their knowledge of different energy data sources and the uses for this information.

There is not and, indeed, never has been a satisfactory overview of the whole energy sector nor a single clearing house for information. There has never been one single "energy statistics" publication, even in the height of political absorption with energy. Different emphases and sets of data appeared and continue to appear in different documents under the auspices of different organisations.

The 1983 review committee saw its major achievement as the formulation of a framework, known as the Energy Matrix, for the development of energy statistics. However, there is a greater range of crucial energy statistics than can be accommodated in the Energy Matrix, as will become clear below. The Energy Matrix is only a framework for a subset of energy data.

One of the "high priority" recommendations of the 1983 review committee was the production of an annual volume of energy and mining statistics. Such a publication has not appeared; although the Energy Data File has been expanded and is the nearest thing to such a publication, it has important omissions.[1] Such an overview should present trends over time (4.2), "balanced" data (4.3 and 4.4), link energy with the economy (4.5), provide yardsticks for comparison with other countries (4.6), contain high quality data (4.7), and be accessible to the public (4.8).

4.2 Time series

Fundamental to an overview of the energy sector are time series of various parameters. The identification of trends is the primary task for the energy analyst.

> *"... of all the energy types, coal is the only one with any real historical data series. Data collection beyond the very broadest levels of aggregation only started for electricity in 1968/69, for petroleum fuels in 1974/75, and for gas in 1980/81"* (Brown Copeland, 1984, p.7).

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[1] It may seem that we have been rather harsh on those currently providing energy data; that is not our intention. The Energy Data File has received particular criticism simply because it is the nearest thing to an overview currently prepared on a regular basis.

The trend toward privatisation is not helpful since the market has a short time horizon. Annual reports tend to be just that; for instance, Electricorp's annual reports compare the year with only the one before. In contrast, the use of a consistent format in the annual electricity statistics (NZED, 1978-88, Ministry of Commerce, 1991) means that time series can be readily extracted.

The only publication that actually presents energy time series on a regular basis is the Energy Data File. Tables on various energy types give annual data for the last 16 years and monthly data for the last 27 months. Time series are also given for the composition of primary energy, for prices of petroleum products and for the country's oil import bill. The Energy Matrix is now generated for the most recent two years.

The designers and producers of the Energy Data File are to be commended for this unusual commitment to continuity. The File's inadequacy as an overview is not because it is too static, but because important data sets are absent.

4.3 A paucity of demand data

One of the major imbalances in energy information in this country (and in most others) is the asymmetry in our knowledge of supply and demand. We know very precisely where our energy comes from, but have only a vague idea of how it is used. This is a problem endemic in energy data sets; it is common to have good data on energy supply right down to the last barrel of oil but have little idea of the ultimate fate of that barrel.

This imbalance is very noticeable in the Energy Data File, in which virtually all the data is supply-side. The only demand-side data appear in the Energy Matrix where the amounts of various fuels used by four very aggregated sectors - industrial, commercial, domestic, and transport - are recorded.

More detail on energy demand in New Zealand can be found in the annual energy statistics series published by the International Energy Agency (IEA, 1960-90). The IEA energy balances take the same form as the New Zealand Energy Matrix, but far more information is given on energy demand. In the IEA reports, industry is broken down into 14 categories and more detail is given on the other sectors. The irony of this situation has not been lost on one analyst.

> *"To get systematic information about the energy sector of the New Zealand economy, we are now dependent upon overseas bodies such as the International Energy Agency, which has continued to demand from the New Zealand Government a degree of statistical accounting that is denied to ordinary New Zealand voters and taxpayers"* (Bertram, 1990b, p.2).

The 1983 review committee recommended that the "final consumption" part of the matrix be presented by standard NZSIC sectors plus two more - household consumption and consumption of energy by the energy industries (Department of Statistics, 1983, 3.2.3). This would give 43 demand categories.

The situation is somewhat better for electricity than for other fuels. Following an Australian Electrical Industry Classification, electricity consumption has been presented in 18 categories since 1965 (Department of Statistics, 1983, 3.28.7). However, it is taking longer than the five years recommended by the 1983 review committee for these 18 categories to be replaced by the more useful 43 categories.

The lack of data on energy demand was increasingly recognised by the NZERDC and one of their last publications was titled *"Guide to sources of data on national energy consumption"*. This project was initially aimed at producing *"time series data sets stratified by the NZSIC ... for energy consumption in New Zealand between 1950 and 1980"* (Brown Copeland, 1984, p.118), but this goal proved elusive.

There is a further level of demand-side data that is even more scarce than demand by economic sector. This is consumption by end use or activity. Some would argue that such information is essential for designing policies to encourage the efficient use of energy or energy management. Resource estimates for conventional fuels like hydro and coal have been prepared by the Energy and Resources Division; why not a report titled *"Reserves of conserved energy"*? A major barrier to the development of an energy management industry is ignorance of the most promising market opportunities.

One objective of the 1984 NZERDC contract on energy consumption information was *"to explore energy use by activity"*. The researchers found this an impossible task. Neither energy suppliers nor the Department of Statistics collected end use data; the only source was found to be (and remains) *ad hoc* research reports, which did not cover the whole economy, generally focused on a short time span, followed different formats and were incompatible (Brown Copeland, 1984, p.119).

4.4 A paucity of stock data

A second major imbalance in energy information in New Zealand is the asymmetry in our knowledge of stocks and flows. We know very well the rates at which we are using various fuels and very poorly the size of the stocks from which we are drawing.[2] Again this imbalance is very noticeable in the Energy Data File. All the data in this describe flows of energy, arguably to an excessive level of detail.

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2 The Energy Data File uses the word "stock" in the sense of "stockpile", for example, a stockpile of already mined coal. We use the word "stock" in the more general sense of resource size.

There are good reasons for this imbalance, the chief one being that resource assessment is a complex uncertain exercise and, in most cases, such assessments are not updated annually.

A fundamental conflict over the public's right to know stock estimates remains unresolved. Stock estimates are often claimed to be *"commercially sensitive"*. However, it is difficult to envisage an energy policy that does not need information on resource assessments, especially if "sustainable management" is a goal or if there is to be any element of national self-sufficiency. Certainly, there is great public interest in the size of oil and gas reserves. In contrast with energy, the assessment of fisheries and consequent setting of harvest quota is widely accepted.

Strangely, information on resource assessments seems to be becoming increasingly available. In 1988, the Ministry of Energy published *"Coal resources of New Zealand"*. Such information given *gratis* to the private sector seems inappropriate in the new more market environment. Yet not only has the Ministry of Commerce published *"Hydro resources of New Zealand"* in 1990, but *"Petroleum resources of New Zealand"* and *"Geothermal resources of New Zealand"* are currently being prepared.

Although this resource assessment information is being published, there seems to be no conscious linking of stocks and flows. Within the Energy and Resources Division the collection and dissemination of information on flows is kept separate from that on stocks. Later in this publication it will be shown how resource accounts can link stocks and flows and give internal consistency to time series.

4.5 Links with economic data

Links between energy and economic data must be established if energy and related environmental concerns are to be taken account of in decision making. It took the energy researchers of the seventies some time to learn that the wonders of a particular piece of hardware would go unappreciated if the energy it supplied cost too much. Price series of various fuels are essential <u>microeconomic</u> energy data.

The latest Energy Data File contains annual series (for the last 19 years) of the retail price of different petroleum products, in both current and constant dollars. There are no price series for other fuels and it is not clear why only petroleum products have been singled out.

Annual electricity prices by consumer category and region can be found in the annual electricity statistics (e.g. Ministry of Commerce, 1991, pp.46-47), so price series in constant dollars could be produced.

The Department of Statistics does not publish prices but does produce series of various price indices. However, these do not give the price indices separately for different fuels as the NZSIC classification groups energy industries together - crude petroleum and natural gas are together in one division, electricity, manufactured gas and water in another. The 1983 review team decided that users of energy price statistics are *"adequately catered for as all major energy products are priced and indexes can be calculated for any combination of these if necessary"* (Department of Statistics, 1983, 8.6.4). This is so; separating out, say the CPI for natural gas, can be done as a special request (at a cost), but is not published information.

For price information to have much meaning it should be presented very carefully. In different publications, prices are given for fuels at different points on the supply-demand chain. In looking at the price series for petrol in Table 7.1 in the Energy Data File, for instance, there is no way of knowing whether a jump in price was mostly due to a jump in cost or an increase in petrol tax.

The more neglected linkages are those between energy and macroeconomic data. Energy consumption by standard economic sector is seen as increasingly important because it enables energy and related environmental concerns to be studied using models of the economy. Energy use statistics would become compatible with other statistics produced by the Department of Statistics.

Energy consumption by economic sector forms a much better basis for demand modelling (and forecasting) than do crude GDP and population projections. Currently, interest is focused more on environmental concerns than on forecasting (although the two are locked together). Strategies like carbon taxes for achieving the Government's carbon dioxide reduction target can be tested in macroeconomic models.

One series of energy-economy data bases exists in New Zealand. The energy input-output tables developed at the University of Canterbury show the energy intensity of different economic sectors in MJ/$ (e.g. Wright, 1990, pp.30-31). These tables have been produced at 5-yearly intervals because they follow the Inter-Industry Studies published by the Department of Statistics.

4.6 International comparisons

The ability to make cross-sectional comparisons is a vital characteristic of good energy information. Internally, good energy analysis requires a comparison of one economic sector with another and a comparison of one fuel with another. Externally, international comparisons provide yardsticks for measuring energy performance with, in particular, trading partners.

This comparison is done to a certain extent for us by the International Energy Agency. However, although the IEA regularly publishes *"Energy balances of OECD countries"*, these publications are not readily accessible.[3]

4.7 Data quality

A data set is of dubious use if it is of poor quality; in fact, it may be seriously misleading if data are used without appropriate caveats. The energy sector is so complex that the problem of data quality is particularly acute. Different sets of information will have very different confidence levels.

Good work has been done in the area of standardisation. The NZERDC established standard definitions and conversion factors with the publication of Baines (1984). The 1983 review team also made some recommendations designed to reduce confusion such as *"... the Energy Matrix be compiled on the basis of net calorific values"*; this recommendation was not adopted.[4]

There are some disconcerting data quality problems in the Energy Data File, although in some cases it is not clear whether they are actually data quality problems or communication problems. It is unnerving to find that the rows in the oil supply tables do not balance, although forced balances are not desirable. But this does not explain why the rows in the first table, which does have a column titled "statistical error", do not balance. Neither does there seem to be a good reason for this being the only table containing such a column.

There appears to be a particular problem with liquified petroleum gas (LPG). LPG features in Table 1.30 (where it is combined with natural gas liquids) and in Table 3.1 because it is extracted from both gas and condensate. However, the indigenous production of LPG in the Energy Matrix is only that extracted from condensate and cannot be the total amount.

A perennial problem for energy analysts is the conversion of electricity to its thermal equivalent. A kWh of electricity is converted to 3.6 MJ of heat when run through a resistance heater, but it takes about 11 MJ of fuel to generate this same kWh in a thermal power plant. In terms of primary energy does 1 kWh equal 3.6 MJ or 11 MJ? This dilemma is particularly acute in New Zealand because of our abundance of

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3 The University of Canterbury library, for instance, holds only part of the series.

4 Net calorific values are considered a better criterion for comparing the energy contents of different fuels in practice than are gross calorific values. However, the Ministry of Commerce uses gross calorific values.

hydropower; it makes international comparisons difficult. An important aspect of data quality is the presentation of caveats and explanations when difficulties like these arise.

The Energy Data File actually uses both conversions. In Table 4.1 hydroelectricity is converted to primary energy in PJ using the first conversion factor; in Table 6.1 it is converted to primary energy in PJ using the second conversion factor.

Another problem of data quality where qualifiers are needed is where raw data and derived data are mixed. Consider the treatment of thermal generation of electricity in the Energy Data File. The only real data is the GWh generated. Thermal efficiencies are assumed - 33% for gas plants, 30% for coal plants, 10% for geothermal plants[5] - and thus the quantities of fuel used for generating electricity are derived. This is a reasonable thing to do but it is very misleading to express these quantities to five significant figures.

Stronger criticisms can be levelled at *"Energy 88"* (Ministry of Energy, 1988). This document is a brave attempt at providing a broad-ranging overview of the energy sector with explanations of policy changes as well as information. However, it is difficult to be successful when the objectives are so wide.

"Energy 88" is of little value to the serious analyst because assumptions are not spelled out. Data is both given and interpreted; the reader is forced to accept the interpretation at face value. To some extent this is inevitable in such a publication, but obvious errors in the text give the reader little confidence in the information, let alone the interpretation. For instance, the axes on the graphs on pp.21-22 are not labelled, a graph of average real electricity price on p.24 shows domestic price varying between 40 and 60 c/kWh [6] with no note of which year's dollars are used, and the graph on p.33 shows an astonishing amount of oil and LPG being used in the household sector.

The energy information published in the Yearbooks is also prone to error. For example, the 1990 Yearbook shows households consuming 70% of the nation's electricity (Department of Statistics, 1990, p.485).

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[5] This adds to the confusion of our previous point. In Table 6.1 geothermal plants are assumed to have an efficiency of 33%; in Table 6.2 (the Energy Matrix) they are assumed to have an efficiency of 10%.

[6] Presumably, the decimal point has been omitted.

4.8 Accessibility

It would be futile to establish a superb energy data base that no one used. The 1983 Review Committee ranked data dissemination of equal importance to data collection (Department of Statistics, 1983, 11.1.1). Consequently, their final recommendation, which seems to have become lost in the flurry of reform, was:

> *"That as a high priority, the Department of Statistics convene a group of representatives from the departments concerned to discuss and recommend to the Review Committee on the production of an annual volume of energy and mining statistics"* (Department of Statistics, 1983, Recommendation 26).

Dissemination is not equivalent to accessibility. Accessibility is a broader concept and includes concerns like public knowledge of availability, cost and user-friendliness.

Public knowledge of availability is probably very low. In seeking to find out the impacts of the reform of the energy sector on energy data, we found an almost universal assertion that nearly everything had been lost. We found this was not so, but it does reveal a large gap between real and perceived availability.

Cost has already been discussed in Section 3.4. The publication of an annual *"Energy statistics"* would help this situation. Currently, to find data on coal resources one must buy *"Coal resources of New Zealand"* at $30, to find data on the historical production of coal one must buy the Energy Data File at $95 (per year), and to find data on the production of electricity through burning coal one must buy the Annual Electricity Statistics (MoC) at $30. Of course, these can be found in libraries. But all these publications contain both very detailed and very aggregated data; for many purposes only aggregated data is required, yet it is scattered throughout a variety of publications.

The strongest feature of *"Energy 88"* is the serious attempt at user-friendliness. It is encouraging to hear that the Energy Data File is also to become more user-friendly. The Energy Data File is currently seriously marred by a lack of explanation and definition.[7]

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[7] For example, what is meant by *"undertakings"* in Table 3.2? What is meant by the *"line pack variation"* in the notes for the same table?

Summary of Chapter 4

Some energy data sets are available in time series but many are not.

There is an imbalance between supply and demand information; very little information on energy demand (by sector or end use) is available.

There is an imbalance between stock and flow information; far more information is available on energy flows than on energy stocks.

Microeconomic energy data exist in the form of some fuel price series; links with the economy on a macro level are absent.

Comparisons of New Zealand's energy performance with that of other countries are not readily available.

There are many problems with the quality of energy data in New Zealand.

Public knowledge of the availability of energy data is low.

5 The Norwegian energy accounts

5.1 The structure of the Norwegian energy accounts

A full description of the Norwegian experience with resource accounting can be found in Wright (1990). The energy accounts comprise one group of what are termed "material accounts". Material accounts are of three types:

Type I Reserve accounts

Type II Extraction, conversion and trade accounts

Type III Consumption accounts

Type I accounts are records of energy stocks. Type II accounts trace flows of energy through the economy. Type III accounts deal with how energy is used. Thus, the energy accounts are located in a "cradle to grave" framework.

The Norwegian energy accounts have been published in various forms over the last decade and there has clearly been a process of evolution in the presentation of the data. In practice, the structure shown in this chapter is not strictly followed in the presentation of the Norwegian accounts. Some aggregated Type III information is presented in Type II accounts.

Although only Type II accounts are directly compatible with national accounts, all of these energy accounts have counterparts in, or at least elements of, standard financial accounts. Reserves are assets and Type I accounts contain elements of accounts of fixed assets, accounts of "work in progress", profit and loss accounts, and balance sheets. Type II accounts are like double-entry book-keeping accounts and a Type III account is like a set of consolidated divisional accounts.

5.2 Type I - reserves accounts

A critical feature of reserves accounts is how reserves are defined. The Norwegians have adopted the classification system developed in Canada known as McKelvey's box (Wright, 1990, p.41). In this system, reserves are that subset of the total resource base that are "discovered" and "economic". Thus, in the Norwegian material accounts, reserves are *"supposed to be economically exploitable, measured as net numbers and given as unbiased numbers"* (Longva, 1981, p.11).

The form of an energy reserves account depends to some extent on the type of energy. In the Norwegian system, material resources are classified physically as non-renewable, conditionally renewable or inflowing (Wright, 1990, p.39). Reserves of inflowing hydropower and conditionally renewable fuelwood are given as annual average numbers, whereas reserves of non-renewable oil and gas are given as recoverable quantities.

The structure of Type I accounts is as follows:

<u>Reserve accounts</u>

Beginning of period:	Resource base Reserves (Developed, Non-developed)
	Total gross extraction during period
	Adjustments of resource base (New discoveries, reappraisal of old discoveries)
	Adjustments of reserves (New technology, cost of extraction, transport etc., price of resource)
End of period:	Resource base Reserves (Developed, Non-developed)

Source: Alfsen *et al.*, 1987, p.13.

There are two kinds of energy reserves accounts; we have dubbed them Type Ia and Type Ib accounts. The major purpose of Type Ia accounts is to show the potential for development and these accounts contain only stock information, drawing a distinction between developed and undeveloped reserves. Type Ia accounts are not balances, but are updated on 1 January each year. Examples appear as Tables 6.1 (hydro) and 7.1 (oil and gas).

Type Ib reserves accounts are based more directly on the structure given above. In these accounts stocks and flows are linked, providing a check for data consistency. The importance of a clear definition of reserves is critical since many factors beside extraction can change reserve estimates. These factors can be geological like the discovery of new reserves or economic like changes in resource price. An example of a Type Ib oil account appears as Table 7.2.

Type Ib accounts are rather more complex for hydropower since hydro reserves are not "extracted" like oil and gas. Table 6.3 is an example of such an account for hydro reserves.

5.3 Type II - extraction, conversion and trade accounts

The major aim of Type II accounts is to trace flows of energy from extraction through conversion to consumption. The structure of Type II accounts is shown below and an example can be found in Table 10.1.

Extraction, conversion and trade accounts

	Gross extraction (by sector) - Use of resource in extraction sectors = Net extraction (by sector)
	Import (by sector) - Export (by sector) = Net import (by sector)
	Changes in stocks
For domestic use:	Net extraction + net import +/- changes in stock

Source: Alfsen *et al.*, 1987, p.13.

There are two kinds of Type II accounts; again we have dubbed them Type IIa and Type IIb accounts.

Type IIa accounts record the flows of direct energy through the economy; that is, they trace energy goods or energy commodities - tonnes of oil, kWh of electricity,and so on. Table 10.1 is an example.

Type IIb accounts give a more complete picture of energy moving through the economy, in that they record indirect as well as direct energy. Indirect energy is the energy that is embodied in final goods and services. Table 10.2 is an example.

5.4 Type III - consumption accounts

Type III accounts focus on the use of energy.

Consumption accounts:

Domestic use (final use category, commodity)

Source: Alfsen *et al.*, 1987, p.13.

There are two kinds of consumption accounts - the main consumption accounts which show energy consumption by economic sector and the additional accounts which show energy consumption by purpose (or end use).

There are two kinds of main consumption accounts that correspond to the two kinds of Type II accounts; again they shall be referred to as Type IIIa and Type IIIb accounts. Type IIIa accounts show the consumption of direct energy, whereas Type IIIb accounts show the consumption of both direct and indirect energy. Table 11.1 is an example of a Type IIIa account and Table 11.2 is an example of a Type IIIb account.

Examples of additional Type III accounts are given in Tables 12.1 and 12.2.

5.4 Summary of nomenclature

The following summary of the nomenclature used for the different kinds of accounts may be a useful reference.

I Reserves

Ia - Snapshot of stocks
Ib - Time series of stocks

II Extraction, conversion and trade

IIa - Direct energy flows   IIb - Direct and indirect energy flows

III Consumption

Main (sector)

IIIa - Direct energy flows   IIIb - Direct and indirect energy flows

Additional (purpose)

5.5 The Norwegian accounts as models for New Zealand

In the next eight chapters, an attempt is made to construct energy accounts for New Zealand using Norwegian examples as models. In Chapter 6, for example, Norwegian hydro reserves accounts precede the attempt to construct New Zealand hydro reserves accounts.

Chapters 6 through 9 deal with Type I accounts for various fuels - hydroelectricity, oil and gas, coal and conserved energy (sometimes known as "the fifth fuel"). No Norwegian examples exist for the last two. The exercise is incomplete; there is no attempt at producing reserves accounts for geothermal or wind energy, for example.

Chapter 10 deals with Type II accounts, Chapter 11 with the main Type III accounts and Chapter 12 with the additional Type III accounts.

A major use for energy accounts in Norway has been the production of "emissions accounts" for energy-sourced pollutants in order to develop strategies for meeting environmental targets. In Chapter 13, several emissions accounts for carbon dioxide are presented.

Success in locating or compiling such energy accounts for New Zealand has been only partial. The major objective of this exercise has not been primarily the production of such accounts, but rather testing the feasibility of their production with currently available information. For this reason, the New Zealand energy accounts presented in this publication should be treated with caution. Some of them are incomplete and the origins of much of the data are obscure. Further, they do not represent the "latest" information; they have been prepared for a variety of years dictated by access to data.

Summary of Chapter 5

There are three types of energy accounts in the Norwegian system.

Type I are reserves accounts. Reserves are defined as the subset of the total resource base that is economically as well as technically exploitable. Type Ia accounts show the **potential** for development. Type Ib accounts focus on the **security** of indigenous supply.

Type II are extraction, conversion and trade accounts. Type IIa accounts record the flows of **direct** energy through the economy. Type IIb accounts record the flows of **total** energy through the economy.

Type III are consumption accounts. Type IIIa accounts record the consumption of **direct** energy by economic sector. Type IIIb accounts record the consumption of **total** energy by economic sector. Additional Type III accounts record consumption by **purpose or end use.**

6 Hydro reserves accounts

6.1 Norwegian examples

Tables 6.1 and 6.2 are Type Ia hydro reserves accounts where the intent is to show the potential for development.

A key feature of both these accounts is the "economy-class" ranking. The economic classification system is not based on a simple öre per kWh generated calculation; a seasonal factor is included since power generated at different times of the year has different values. A second common feature is the development stage of the reserves.[1]

Table 6.1 A Type Ia account. Reserves of hydropower in Norway at 1st January, 1987. GWh/yr.

Watercourse	Average annual production	Economy-class
Developed at 1 January 1987	102,716	
Concession granted	4,447	
Jostedalen	879	3
Kobbelv	711	3
Alta	625	1
Others*	2,241	
Concession applied for	12,217	
Holandsfjord	1,980	3
Glitra	830	1
Skåre	825	5
Stavem	768	2
Øyberget	507	1
Others*	7,307	
Prior noticed	6,559	
Grong	538	3
Trofors	1,203	4
Others*	4,818	

* Projects with mean annual production of less than 500 GWh.
Source: Central Bureau of Statistics, 1988, p.63.

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[1] These accounts are supplemented by other information including the generation potential in permanently protected rivers.

Table 6.2 A Type Ia account. Available and developed reserves of hydropower in Norway. Mean annual production. TWh/yr.

	Developed 1 Jan. 1987	Not developed 1 Jan. 1987 Total	Economy class 1	2	3	4	5	6
Total	102.7	46.3	5.8	11.0	12.8	9.8	4.2	2.6
Concession granted		4.4	0.7	0.5	2.4	0.2	0.6	--
Concession applied for		12.2	1.9	4.3	2.2	2.0	1.0	0.7
Prior noticed		6.6	0.4	1.7	1.9	2.1	0.2	0.2
Remainder		23.1	2.8	4.6	6.4	5.5	2.3	1.7

Note: Permanently protected watercourses are not included in the numbers.
Source: Central Bureau of Statistics, 1988, p.64.

Table 6.3 is an example of a Type Ib hydro reserves account. As mentioned in Chapter 5, it is difficult to create a hydro reserves account to fit neatly into the reserves account structure, since hydro reserves are not depleted in the same way as nonrenewable reserves. The focus of this account is reservoir capacity, that is, the backup to the generating system. The intent seems to be to monitor the security of electricity supply.

Table 6.3 A Type Ib account. Hydropower reservoir capacity and reservoir supply in Norway. 1980-86.

	1980	1981	1982	1983	1984	1985	1986
				TWh			
Reservoir capacity at 1.1	57.3	58.3	61.6	63.4	64.8	65.5	73.6
Change during the year	1.0	3.3	1.8	1.4	0.7	8.1	0.2
Reservoir capacity at 31.12	58.3	61.6	63.4	64.8	65.5	73.6	73.8
Reservoir supply at 31.12	38.4	43.1	47.2	52.0	51.2	47.3	56.6
				As percent of reservoir capacity			
Reservoir supply	65.9	70.0	74.4	80.2	78.2	64.3	76.7
Maximum supply	82.4	94.6	91.3	98.2	93.9	86.7	81.9
Minimum supply	26.7	25.2	24.4	34.2	31.7	21.2	23.0

Source: Central Bureau of Statistics, 1988, p.66.

6.2 Type Ia hydro accounts

At first sight, Table 6.4 looks similar to Table 6.1. But there is no economic classification and the table is a mix of reserves and resources.

Table 6.4 A Type Ia account? Existing and potential hydro-electric resources in New Zealand. 1986.

Status	GWh per year	Totals
Existing		22,000
Under construction and proposed:		
Clyde	1,900	
Luggate	400	
Queensberry	800	
Lower Clutha 1	900	
Total		4,000
Detailed studies complete:		
Lower Clutha	1,100	
Lower Waitaki	3,700	
Total		4,800
Investigation/prefeasibility:		
Mohaka	1,200	
Rangitikei	900	
Clarence-Waiau	3,200	
Buller	2,900	
Total		8,200
Preliminary survey - over 250 GWh/yr		13,000
Preliminary survey - under 250 GWh/yr		13,000
Precluded from development by National Water Conservation Order (NWCO) or under consideration for NWCO		
Kawerau	700	
Motu	1,600	
Wanganui	1,700	
Rakaia	3,000	
Total		7,000
Grand total		72,000

Source: Ministry of Energy, 1986, p.57.

"Hydro resources of New Zealand" (Mills *et al.*, 1990) is a summary of many years of work identifying and evaluating undeveloped hydro resources in New Zealand. The authors describe a large number of potential hydro schemes over 10 MW. The summary table from Mills *et al.*'s report appears as Table 6.5.

Table 6.5 A Type Ia account? Existing and potential capacity of hydro schemes in New Zealand.

Region	Total existing capacity (MW)	Potential capacity					Total Capacity (MW)
		Potential for development				Total	
		1	2	3	4		
Northland	-	-	7	-	-	7	10
Auckland	-	-	-	-	-	-	-
Waikato	1360	40	25	50	50	165	1528
Bay of Plenty	157	15	285	325	-	625	782
Taranaki	32	25	20	-	-	45	77
Manawatu-Wanganui	20	20	410	355	145	930	950
Gisborne	-	-	-	70	-	70	70
Hawkes Bay	124	185	265	50	30	530	654
Wellington	-	-	35	45	-	80	80
Total North Island	1693	285	1050	895	225	2455	4151
Nelson-Marlborough	43	60	470	30	-	560	603
West Coast	-	365	2000	705	735	3805	3805
Canterbury	1818	960	1240	85	595	2880	4698
Otago	837	700	320	275	90	1385	2222
Southland	590	-	230	150	915	1295	1885
Total South Island	3288	2085	4260	1245	2335	9925	13213

Source: Mills *et al.*, 1990, p.54.
Note: There are some small addition errors in this table.

Table 6.5 looks remarkably similar like Table 6.2. But closer examination reveals three differences.[2] The first is minor; the potential is expressed in terms of capacity (MW), not in terms of average annual production (GWh per year)[3]. The second difference is that the Norwegian estimates have excluded protected rivers, whereas the New Zealand estimates have not. The third difference is the most problematic; instead of a well-defined economic ranking, there is a vague generalised development ranking. (Schemes are ranked 1, 2, 3 or 4 according to their *"potential for development"*.)

The first difference can be readily eliminated by changing MW to GWh per year. For this transformation to be done correctly, one would need estimates of the plant factors

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[2] There is possibly a fourth difference. Reserves in the Norwegian framework are supposed to be net of energy used in construction and operation. Annual power station productions reported by Electricorp are net of operating energy only.

[3] This seems odd since the New Zealand generating system is energy-constrained, not power-constrained.

of all the proposed schemes. However, there is little reason for such accuracy when the MW figures are estimates; a 50% plant factor would be a reasonable average.

The second difference could be eliminated by some investigation. In the text of *"Hydro resources of New Zealand"*, rivers protected by National Water Conservation Orders (NWCOs) or with NWCOs lodged are identified. Further, many of the schemes are within National Parks. But the report does not contain sufficiently disaggregated information for potential schemes on protected rivers to be subtracted. The presence of such protection is presumably factored into the development ranking, but schemes on rivers with NWCOs do not appear to receive automatically a ranking of 4 or even 3. Perhaps *"permanently protected rivers"* in Norway are more firmly protected than New Zealand rivers with NWCOs.

The third difference has proved to be virtually insurmountable in the present information climate. Presumably, the *"potential for development"* ranking does include economic viability, but it is weighted in with engineering viability and environmental factors. The weighting given to these various factors is not revealed.

Before corporatisation, the Ministry of Energy published information on the costs of proposed power plants. For instance, the 1985 Energy Plan contains c/kWh data on various schemes for a range of plant factors and two discount rates.

Now the situation is quite different. Naturally, Electricorp considers such information *"commercially sensitive"*. Some rough historical information is still available; for instance, at the Planning Tribunal hearing of the Wanganui River minimum flows appeals, one witness supplied the costs of four hydro development options - Luggate and Tuapeka on the Clutha and two schemes on the Mohaka (K. Turner, 1990, Exhibit KST13).

In an attempt to extract "economic ranking" from "development ranking", we have tried to match the costs of the four hydro options in this evidence to schemes in Mills, *et al.* This proved impossible because of the level of aggregation. For instance, there are five potential schemes on the Clutha with rankings from 1 to 4; the reader is not told the rankings of Luggate and Tuapeka.[4]

One source of the costs of potential hydro projects is the series of reports on "small" hydro schemes published by the NZERDC and others.[5] In these reports, costs are given in terms of $ per kW and can be scaled to 1991 dollars using the construction

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[4] The costs of the hydro options in the Electricorp evidence are very approximate; they are given to the nearest hundred million dollars.

[5] "Small hydro" was defined as 50 MW or less, although most of the schemes were 20 MW or less.

cost index; energy costs in c per kWh can then be calculated. However, although these reports form the bulk of the references for *"Hydro resources of New Zealand"*, it is impossible to match many of the small schemes with those in the overview publication. In the four schemes we succeeded in matching, one scheme with a ranking of 1 would generate electricity at about 10c per kWh, two schemes with a ranking of 2 at about 11c per kWh in 1991 dollars, and one with a ranking of 3 at about 13c per kWh. It seems that economic viability has been given considerable weighting in the development ranking.

There is little point in slavishly imitating the Norwegian system and it is vital to ask what purposes the disclosure of the costs of potential hydro reserves would serve. In Table 6.1, the economy class ranking does not appear to have had a major influence on the order of development of hydro reserves in Norway; cheaper projects do not necessarily precede more expensive projects. Of course, this may be historical inertia; the publication of reserves accounts may be intended to encourage a more rational investment strategy.

The transformation of certain government departments (including the Electricity Division of the Ministry of Energy) into SOEs was intended to create institutions with incentives for rational investment. The costs of potential hydro schemes seems rather academic at the moment because Electricorp are clearly more interested in squeezing more kWh out of existing plant than in building new hydro schemes. However, a "rational" investment strategy for Electricorp does not necessarily involve building the cheapest plant first; the cheapest plant may be environmentally unacceptable.

But Electricorp remains a state monopoly and the greater the market power of a state institution, the greater the information they should be required to divulge. On this principle rests that catchword of public sector reform, *"accountability"*. There will be issues where knowledge of the marginal cost of hydropower is in the public interest. Three such current issues come to mind.

One obvious issue has already been referred to in Chapter 2, that is, the continued subsidy of the Clyde dam by the taxpayer.

A second issue is the proposed sale of the country's prime developed hydro reserve, the Manapouri power station. If it is sold, there can be no public judgement of the price without information on the costs of replacement schemes.

A third issue is the concern over the greenhouse effect which has already found political expression in the setting of a carbon dioxide reduction target. If a serious attempt is to be made to reach this target, then there will be pressure on Electricorp to substitute thermal generation with hydro and other forms of generation including energy efficiency. If Electricorp is required by the Government to, for instance, build a new hydro station that will generate at 10 c/kWh instead of a new thermal station that will generate at 5 c/kWh, these costs (and alternatives) should be publicly discussed as part of the political process.

In all of this there is a question mark over the quality of the information. The costs of power from new hydro schemes have been seriously underestimated in the recent past. The Clyde dam is not the only hydro scheme where costs were seriously underestimated. The *"Review of electricity planning and electricity generating costs"* (The Treasury, 1985) revealed an embarrassing history of underestimating costs.[6] [7]

Table 6.6 Power costs for six hydro schemes in New Zealand. Cents per kWh (1983 dollars).

	Submission costs	Actual costs
Atiamuri	7.5	11.8
Aviemore	6.1	4.2
Benmore	5.9	3.9
Tongariro	6.9	13.7
Upper Waitaki	3.8	5.7
Manapouri	1.9	3.0

Source: Adapted from The Treasury, 1985, p.4.
Notes:
1. Multiplying costs by about 1.6 scales them to current (1991) dollars.
2. An actual energy cost of 21.1 c/kWh for Tongariro is also given; this refers to the costs without the downstream benefits added.

Table 6.5 is the nearest to a Type Ia hydro reserves account that it seems possible to construct. One can only assume that *"potential for development"* is at least a partial proxy for *"economic cost"*. But without a well-defined economic ranking, Table 6.5 remains an account of <u>resources</u> not of <u>reserves</u>. Many of the schemes could be extremely expensive and the likelihood of their ever being built, minimal. The total undeveloped hydro resource is given as 12,380 MW; the total undeveloped hydro reserve is likely to be, at most, those schemes with a ranking of 1, that is, 2,370 MW.

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6 This was not confined to hydro stations; Huntly was supposed to generate at 3.6 c/kWh, but actually generated at 7.4 c/kWh (1983 dollars).

7 Small hydro projects have fared no better. A report on local hydro-electric power schemes showed seven out of ten schemes running over budget. The average increase (weighted by plant capacity) in unit costs was 39% (Audit Office, 1987).

6.3 Type Ib hydro accounts

Table 6.3 has been given earlier in this chapter as an example of a Type Ib hydro account with the security of electricity supply as its focus.

Virtually all electricity in Norway is produced from hydro stations and so hydro storage capacity assumes an importance it does not have in New Zealand where thermal stations provide the backup. The nominal capacity of hydro storage in New Zealand is 3641 GWh, only 13% of annual demand (M. Turner, 1990, p.14), whereas in Norway, reservoir capacity is about 70% of annual demand.

Table 6.3 is an annual account and attention is focused on reservoir capacity and supply at the end of the year. In Norway, the end of the calendar year is a critical time for electricity generation since demand is at its peak and there is little rain or melting snow in winter. Thus, reservoir supply on 31 December is a useful indicator in Norway and, by good accounting fortune, happens to be the end of the calendar year.

In New Zealand, the situation is more complex because hydro lakes peak at different times in the North and South Islands, although South Island storage dominates the total (M. Turner, 1990, p.23).

This type of reserves account is not as relevant to measuring the security of electricity supply in New Zealand as it is in Norway. Yet security of supply (or over-security) is still an issue of public interest. Reserve capacity is often cited as a measure of supply security.[8] However, dry year energy margin is of more interest here with our now energy-constrained system.[9]

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[8] Reserve capacity is the margin of operating capacity over maximum demand and is currently about 40% (K. Turner, 1990, p.24). It can be calculated from data published by Electricorp in its annual reports.

[9] The dry year energy margin is calculated from the economic dry year energy production capability of the system (based on 95% reliability) and the total annual energy produced. With Clyde operational, the New Zealand dry year energy margin will be around 26% (K. Turner, 1990, p.25).

Summary of Chapter 6

Many surveys have been done of the potential for hydroelectric schemes.

These studies do not produce Type Ia reserves accounts but resources accounts because economic rankings are not given. Also they are not updated annually.

The costs of several hydroelectric schemes (both large and small) have been seriously underestimated in the past. The release of pre-construction costings did not prevent this.

The production of Type Ia hydro reserves accounts would probably be impossible in the current institutional environment.

Type Ib hydro accounts are not a relevant measure of the security of electricity supply in New Zealand.

7 Oil and gas reserves accounts

7.1 Norwegian examples

Table 7.1 is part of a Type Ia account where the intent is to show the potential for development. No economic ranking is given in this table; presumably, all this oil and gas is classed as "economic". In *"Miljostatistikk 1988"*, this table is accompanied by a map and information on the various fields - when the field was discovered, when production began and the "operator" of the field.

Table 7.1 A Type Ia account. Reserves of oil and gas in Norwegian waters south of 62°N. Million tonnes oil equivalent.

Field	Oil	Gas
Total resources proven	1279.6	2332.3
Fields in production:		
Albuskjell	1.5	5.7
Cod	0.4	1.6
Edda	0.7	0.2
Ekofisk	95.7	74.1
etc.		
Total in production	602.7	281.8
Field decided developed:		
Oseberg	173.8	71.0
Sleipner ϕst	23.5	51.0
Tommeliten	5.6	16.8
etc.		
Total decided developed	202.9	976.8
Fields not decided developed:		
Agat	-	43.0
Balder	28.0	-
Brage	23.0	6.0
etc.		
Total not decided developed	474.0	1073.7

Source: Adapted from Central Bureau of Statistics, 1988, p.67.

Table 7.2 is an example of a Type Ib account. This account conforms neatly with the reserves account structure described in Chapter 5. The reasons for changes in reserves can be readily seen and the time series in the bottom row gives a sense of the security of indigenous supply.

Table 7.2. A Type Ib account. Reserve accounts for crude oil in Norway. Fields in production and decided developed fields. 1980 - 1987. Million tonnes.

	1980	1981	1982	1983	1984	1985	1986	1987
Reserves at 1 January	520	496	509	495	495	650	733	838
New fields	24	80	-	38	147	65	29	58
Re-evaluation	-24	-43	11	-7	43	56	118	4
Extraction	-24	-24	-25	-31	-35	-38	-42	-49
Reserves at 31 December	496	509	495	495	650	733	838	851

Source: Central Bureau of Statistics, 1988, p.66.

7.2 Type Ia oil and gas accounts

Consistent information on the size of New Zealand's oil and gas reserves is elusive. There are several sources of information but it has been impossible to reconcile them. Such estimates, of course, have considerable uncertainty attached to them[1] but there are other problems.

One time series can be found in the Energy Plans. These estimates do appear to vary as reserves are depleted and new fields discovered. However, they carry little indication of the reliability of the data. In only two cases are estimation dates given - January 1980 in the 1980 Plan and April 1983 in the 1983 Plan.

A second publicly available time series can be found in the Yearbooks. However, these estimates do not take account of subtractions from and additions to the total and remain essentially constant between geological surveys. The Yearbook estimates do

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1 Although uncertainty is sometimes acknowledged and its degree estimated, the sizes of reserves are generally given with a misleading number of significant figures. Some early expressions of certainty have proved very misguided. For example, the statement in the 1982 Energy Plan that "*The Kapuni field has been in operation since 1970 and the reserves are known accurately...*" is extraordinarily overconfident given the benefit of hindsight.

mostly include estimation dates and probability levels[2]. As with the Energy Plans, all units are Petajoules with the exception of the 1990 Yearbook where oil/condensate is given in millions of barrels and, more strangely, gas is given in billions of cubic feet[3].

Some information is available from the private sector, for instance in Petrocorp's prospectus. Information on reserves is given in Petrocorp's 1988 and 1989 Annual Reports, but not in their 1990 Annual Report.

The most consistent time series is that given in the Energy Plans; however, these ceased in 1986, although *"Energy 88"* contains reserve estimates. The Energy and Resources Division of the Ministry of Commerce will supply information on current reserves, but not by field as this is considered commercially sensitive"[4]. However, the Ministry is intending to release a publication titled *"Petroleum resources of New Zealand"* late in 1991. This should give a good basis for oil and gas reserves accounts, provided some kind of annual update is available.

In contrast with hydro reserves, the definition of oil and gas reserves is consistent with that required for resource accounting. Reserves estimates are generally given as *"recoverable reserves"* with the difference between technical and economic recoverability within the margin of error. Maui reserves of gas, condensate and LPG are reported by Petrocorp as significantly smaller than the amounts ultimately recoverable.

There is possibly one inconsistency in the definition of reserves. A considerable amount of energy is invested in the extraction and processing of reserves. Almost certainly, the figures used are for "gross" not "net" recoverable reserves.

Table 7.1 gives the Norwegian reserves of oil and gas in three categories - fields in production, fields decided developed and fields not decided developed. In New Zealand, it is only the first category that is readily available.

Table 7.3 gives the New Zealand reserves of oil and gas for fields in production. Some information on undeveloped fields can be found in newspaper reports, a less than satisfactory source. For example, the Kupe South field has been reported as containing

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[2] Probability levels are given as 65% in the 1979 to 1984 Yearbooks and as 90% in the 1985 and 1986 Yearbooks. In the 1987 Yearbook no figure is given; presumably there were indications that the huge Maui reserve had been significantly overestimated. In the 1988-89 Yearbook, low, middle and high values are given, but in the 1990 Yearbook there is a return to single values.

[3] These numbers are difficult to convert to Petajoules because of the differing average calorific values of gas and oil/condensate from different fields and so the time series is broken.

[4] It seems odd that the 1990 Yearbook gives oil/condensate and gas reserves by field.

"proven or probable" reserves of roughly equal amounts of gas, LPG and oil totalling about 620 PJ with production expected to begin in 1995 (Christchurch Press, 12/11/90).

Table 7.3 A Type Ia account for oil and gas in New Zealand. 1990.

Field	Oil/condensate		Gas	
	10^6bbl	PJ	10^9ft^3	PJ
Fields in production:				
Kapuni	14.23	85	482.01	350
Maui	89.46	498	2452.00	3276
McKee	22.06	134	93.27	?
Kaimiro	1.20	7	46.11	?
Stratford	0.21	?	7.58	?
Waihapa	16.91	?	18.61	?
Tariki	1.50	?	43.53	?
Ahuroa	0.75	?	28.28	?
Total in production	146.32	>724	3171.39	>3626

Source: Dept of Statistics, 1990, p.485 for the first and third columns. Other numbers have been derived as explained in Note 1.

Notes:

1. The units given in the 1990 Yearbook have been converted to Petajoules using conversion factors in the Energy Data File and information in Baines (1984) and the Petrocorp prospectus. Incomplete and contradictory information made the exercise frustrating, yet Petajoules are essential for a comparison of reserves through time and across fuels. Some of the numbers seem very odd; for instance, Kapuni gas at only 350 PJ. According to the Ministry of Commerce, the Kapuni gas reserve was revised upward to 580 PJ from 405 PJ in 1988 (D. Clover, pers. comm., 1990). This illustrates the importance of good quality data; either the Yearbook is out of date or the conversion factors in the Energy Data File are wrong. (The latter are very different from those given in Baines (1984).) Certainly, the degree of confidence implied by the number of significant figures given in the Yearbook data is misplaced.

2. The size of the Waihapa field has been revised upward with the Ngaere discovery; the reservoir under Waihapa and Ngaere is now recognised as a single field.

7.3 Type Ib oil and gas accounts

Compilation of Type Ib accounts for oil and gas requires not just dated reserve estimates but also information on annual extractions, new discoveries and changes in reserve estimates due to new geological surveys, production performance and to price movements[5]. The last is probably within the margin of estimate error.

In the Energy Plans, new discoveries of oil and gas fields were reported somewhat haphazardly. Annual extractions (indeed, monthly extractions) are given in the Energy Data File. However, there are at least two complications in working out precisely which numbers record the actual offtake from reserves.

The first is liquified petroleum gas (LPG). LPG comes from two sources; it is extracted from the wellhead gases and produced as a result of stabilising the condensate.[6] How much LPG is extracted from the reserves of oil/condensate and how much from the reserves of gas? The early Energy Plans show LPG included in both reserves of oil/condensate and gas. Presumably, columns titled *"NZ production"* of *"crude oil"* and *"gas"* in the Energy Data File include LPG in both cases. Information from the private sector records reserves of crude oil, condensate, dry gas and LPG separately.

The second complication is the reinjection of gas that occurs at Kapuni. Kapuni is a retrograde field and gas is reinjected to keep the pressure high in order to minimise phase separation; the reinjected gas also acts as a "sweeper". About half the gas at Kapuni is reinjected; some will ultimately be extracted. Hence in calculating gas offtakes, the *"gas reinjected"* must be subtracted from the *"gross natural gas production"* recorded in the Energy Data File.

Tables 7.4 and 7.5 are attempts at constructing Type Ib accounts for oil/condensate and gas in New Zealand. The exercise of producing these tables was instructive. The accounts are not "correct" since they do not balance; that is, the number at the bottom of each column should be identical to that at the top of the next column.[7] The discrepancies are greatest in the later years. Most of the data in these tables were taken

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5 A significant increase in the price of oil may make enhanced recovery (by, for instance, fracturing the sandstone matrix) or the development of a small field worthwhile.

6 The Energy Data File appears to give separate values for these two sources of LPG. In the liquid fuels section, production figures for LPG/NGL are given and in the gas section LPG extracted from natural gas is given. However, in a comparison with figures supplied by the Natural Gas Corporation, it appears that the second is included in the first (J. Seymour, pers.comm., 1991).

7 The differences are small compared with uncertainty in estimates; however, they are significant compared with extractions. The point is that, in a series like the Energy Plans, there should be no differences or, at least, there should be explanations for them.

from Energy Plans[8] and now that these documents are no longer produced the time series of hydrocarbon reserves (estimated on a reasonably consistent basis) has ceased.[9]

In spite of their incomplete status, the accounts below are interesting. The biggest "event" in the time period was clearly the downward revision of Maui. Because of the need for a balance, the accounts provide a consistency check, something that was clearly lacking in the data sources.

Table 7.4 An incomplete Type Ib account for oil/condensate in New Zealand. Fields in production. 1981-88. Petajoules.

	1981	1982	1983	1984	1985	1986	1987	1988
Reserves at 1 April	1115	1087	982	935	1069	1029	900	900
New fields				117		23		
Re-evaluation	?	-28	-25	?	?	-143	?	?
Extraction	-21	-31	-30	-38	-41	-61	-60	-74
Reserves at 31 Mar. next year	1094	1028	927	1014	1028	848	840	826

Sources: Ministry of Energy, 1981 to 1985 (Energy Plans), 1986, 1988; Ministry of Energy, 1981 to 1988 (Energy Data Files); D.Clover, Ministry of Commerce, pers. comm., 1990.

Table 7.5 An incomplete Type Ib account for gas in New Zealand. Fields in production. 1981-88. Petajoules.

	1981	1982	1983	1984	1985	1986	1987	1988
Reserves at 1 April	5945	5874	5814	5750	5776	5663	4293	4319
New fields			22	110		133		
Re-evaluation	?	-12	8	?	?	-1501	175	?
Extraction	-39	-71	-73	-97	-132	-180	-167	-171
Reserves at 31 Mar. next year	5906	5791	5771	5763	5644	4115	4301	4148

Sources: Ministry of Energy, 1981 to 1985 (Energy Plans), 1986, 1988; Ministry of Energy, 1981 to 1988 (Energy Data Files); D.Clover, Ministry of Commerce, pers. comm., 1990.

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8 For this reason, the accounts are based on an April year.

9 The publication of *"Petroleum resources of New Zealand"* by the Ministry of Commerce will be useful, but without updating will not give a time series.

Summary of Chapter 7

For oil and gas reserves in New Zealand, the definition of reserves seems to comply reasonably well with that used in Norway.

It is possible to produce Type Ia accounts from publicly available information, but only for fields in production.

Theoretically, it should be possible to prepare Type Ib accounts for oil and gas covering the period of the Energy Plans. However, in practice, these accounts did not balance which raises questions about the quality of the data. Type Ib accounts are an excellent format for checking consistency.

8 Coal reserves accounts

8.1 Type Ia coal accounts

Not surprisingly, the attempt to prepare reserves accounts for coal that follow the Norwegian model has been plagued by the differences between the way coal reserves are defined in New Zealand and the standard Norwegian definition of reserves. Recall that in the Norwegian system, reserves are *"... supposed to be economically exploitable, measured as net numbers[1] and given as unbiased numbers"* (Longva, 1981, p.11).

In the New Zealand coal resource classification system, the use of the term "coal reserves" is *"... restricted to measured recoverable coal assigned to confidence levels 1 to 3..."* (Anckorn *et al.*, 1988, p.4). The term, *"measured"* relates to the highest level of geological assurance, that is, above *"indicated"* and *"inferred"*. The seven *"levels of confidence"* assigned to mining assurance are carefully defined. However, roughly speaking, a level of 1 is achieved when mining is in progress, a level of 2 is achieved when development is well advanced and a level of 3 is achieved when detailed information is available.

The use of the term *"recoverable"* is not so controlled. In *"The coal resources of New Zealand"*, the emphasis has been placed on technical, not economic recovery.

> *"Some mining studies prepared for the New Zealand Coal Resources Survey have presented estimates of recoverable coal based on alternative least cost and maximum resource utilisation options. The higher figure has been adopted here, justified by the fact that although costs will change with time, non-discounted resource data (reflected by 'maximum resource' figures) will not"* (Anckorn *et al.*, 1988, p.3).

Although two of the summary tables in this publication give "reserves" of coal, neither gives the total reserves according to the definition above. [2]

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[1] It is questionable whether the Norwegians have met this criterion in their own reserves accounts. Subtracting out operating energy is a reasonably straightforward exercise, but estimating the energy investment required to bring a reserve into production is another matter.

[2] Table 4 gives reserves (measured and technically recoverable) for existing mines only and Table 5 gives State Coal reserves only. To add to the confusion, Table 5 gives in-ground as well as recoverable coal and some coal that is indicated or inferred rather than measured. (Anckorn *et al.*, 1988, p.10.)

The Energy Plans contain estimates of the "recoverable reserves" of coal but use yet another definition of reserves. Coal of all levels of geological assurance and mining assurance is apparently included in these estimates.

In the Energy Plans, reserves appear to differ from resources by being "recoverable", in more than just a technical sense. *"To be classified as recoverable, the deposit should also be able to be mined at a reasonable cost"* (Ministry of Energy, 1982, p.26). The application of this criterion seems to have been somewhat less than rigorous. An early Energy Plan records the assumption that 50% of South Island lignite is economically recoverable (Ministry of Energy, 1980, p.8); in other Energy Plans the assumptions are not recorded.

The exception is the 1985 Plan, in which resource costs were attached to specific coalfields; these were updated the following year in *"Energy issues"* (Ministry of Energy, 1986). Table 8.1 is a Type Ia account prepared from this information. However, it is difficult to have much faith in the estimates. For three fields in this table, Pike River, Kaitangata and St Bathans, the recoverable reserves are considerably greater than the recoverable resources in Anckorn *et al.*.

Table 8.1 Type Ia account for coal "reserves" in New Zealand. 1986.

Coalfield	Petajoules	$/GJ
Maramarua	1000	2.0 - 7.5
Waikare	500	4.5 - 7.0
Mokau	2000	2.5 - 4.0
Pike River	1000	3.0 - 5.0
Greymouth	200	2.5 - 4.0
Kaitangata	10000	1.0 - 6.0
St Bathans	11000	1.0 - 3.0
Roxburgh	2000	1.5 - 3.5
Croydon	4000	0.5 - 1.0
Ashers-Waituna	9000	1.0 - 1.5
Waimatua	9000	1.0 - 2.0
Morton Mains	7000	1.5 - 2.5
Mataura	9000	1.0 - 2.5
Waimumu	2000	2.0 - 4.0
Imports from Australia		3.0 - 9.0

Source: Adapted from Ministry of Energy, 1986, p.42.
Note: Conversion from million of tonnes to PJ has been done using field-specific information in Anckorn, *et al.* (1988) and Baines (1984).

8.2 Type Ib coal accounts

The basis of a Type Ib account is a time series of reserve estimates; the series titled "recoverable reserves" that is given in the Energy Plans should suffice. Table 8.2 is the result of a rather futile attempt to construct a Type Ib account for coal from this series. Although the reserve estimates are not consistent with the official New Zealand definition of reserves, let alone the Norwegian definition, they have been used because they form the only series available.

The tables of coal reserves in all the Energy Plans give a breakdown by geological assurance and the later Plans give a breakdown by mining assurance as well. However, the disaggregation is inadequate for isolating reserves consistent with the New Zealand definition. Because of this and for consistency with Table 8.1, "total recoverable reserves" are given in Table 8.2.

The Energy Plans are not consistent in their use of conversion factors. Up to the 1982 Plan, calorific values are given as 29 MJ/kg for bituminous coal, 23 MJ/kg for sub-bituminous coal and 12 MJ/kg for lignite. In the 1985 and 1986 Plans, these have been changed (although not explicitly) to 31, 21 and 14 MJ/kg respectively.

The changes in reserve estimates in Table 8.2 are presumably due to re-evaluation. Extractions of coal are unlikely to have been taken into account; of course, these extractions are small compared with the size of the resource, but the principle of balance should hold. In fact, the quantities of coal extracted are small compared with changes in calorific values and can even be eclipsed by a different predilection for rounding off estimates.

Table 8.2 Type Ib account for coal "recoverable reserves". PJ.

	1980	1981	1982	1983	1984	1985
Reserves at 1 April:						
Bituminous	5120	4960	4960	4900	4990	5180
Sub-bituminous	12750	16170	15650	15290	15310	13820
Lignite	40960	40880	51530	77270	77270	77450
Total	58830	62010	72140	97460	97570	96450
New fields	-	-	-	-	-	-
Re-evaluation	?	?	?	?	?	?
Extraction	53	54	55	61	62	62
Reserves at 31 March next year	?	?	?	?	?	?

Source: Ministry of Energy, 1980-85 (Energy Plans and Energy Data Files).
Note: Conversion factors from mass units to energy units were 31 MJ/kg for bituminous coal, 21 MJ/kg for sub-bituminous coal and 14 MJ/kg for lignite.

Summary of Chapter 8

Difficulties with the definition of coal reserves in New Zealand impede the construction of Type I accounts for coal. The Energy Plans used a different definition of reserves from that prescribed by the New Zealand coal resource classification system. Neither definition is consistent with the Norwegian definition.

Economic information given in 1985 and 1986 by the Ministry of Energy means that Type Ia accounts can be prepared for those years.

Again the impossibility of getting a Type Ib account to balance raises questions about the quality of the data supplied by the Ministry of Energy.

9 Conserved energy reserves accounts

9.1 Conserved energy as energy supply

For some time it has been argued that conserved energy is a resource in the same way as a gas field or falling water or fissile uranium. Every improvement in the efficiency with which energy is used frees up energy for use elsewhere.[1]

> *"The reserves of energy created through conservation do not lie in the ground; rather, they lie in the end uses of energy. Moreover, the reserves are highly dispersed. They are 'located' in inefficient refrigerators, poorly insulated homes, gas-guzzling cars, and inadequate or nonexistent controls for buildings, lights, boilers, and traffic jams"* (Meier *et al.*, 1983, p.viii).

Energy conservation, or energy management, has traditionally been seen as an activity at the demand end of the supply-demand chain. Serious attempts to shift it to the supply end require that conservation potential be analysed in the language[2] and techniques of supply methodologies. One outcome has been the development of the analytical method known as "supply curves of conserved energy" (Wright and Baines, 1985). In Britain, conserved energy has been dubbed the "fifth fuel".

In New Zealand, there is much to do before energy conservation is truly regarded as energy supply. Reference has already been made to the Resource Summaries prepared by the Resource Information Unit of the Energy and Resources Division of the Ministry of Commerce. *"Coal resources of New Zealand"* and *"Hydro resources of New Zealand"* have been published; *"Geothermal resources of New Zealand"* and *"Petroleum resources of New Zealand"* are in preparation. The publication of this information essentially *gratis* seems odd in a user pays environment. Will the Ministry provide free information on market opportunities to would-be investors in an energy management industry by publishing *"Conserved energy resources of New Zealand"*?

There is no reason why conserved energy should not feature in energy accounting. In this chapter, the possibility of developing accounts for reserves of conserved energy is investigated.

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[1] Electricorp is now supplying more electricity, not by building new power plants but by squeezing more electricity out of existing plants. Improvements in efficiency at any point along the supply-demand chain will supply energy.

[2] An early use of such language was the article titled *Drilling for oil and gas in our houses* by M.H. Ross and R.H. Williams published in *Technology Review 82(5)*: 24-36 in 1980.

9.2 Type Ia accounts for conserved energy

The reserves of conserved energy lie in the end uses of energy. The resource of conserved energy lying in a particular end use is the theoretical maximum fraction that could be conserved. The reserve of conserved energy lying in that end use is the fraction that could be conserved economically using current technology.

Consider one major end use of electricity in New Zealand, household water heating. According to one study, in the year 2000, roughly 4.7 TWh of electricity will be used for this purpose (Wright & Baines, 1986, p.67).[3] What fraction of the 4.7 TWh per year constitutes a resource of conserved electricity and what fraction constitutes a reserve?

Resources of conserved energy can, in some instances more readily than others, be calculated from the science of thermodynamics. In 1974, a group of physicists gathered at Princeton University to discuss the efficient use of energy. One result of that gathering, which has significantly influenced energy conservation philosophy and policy, was a new concept of efficiency known as "second law efficiency", as a complement to the common concept of physical efficiency, "first law efficiency"[4] (Carnahan *et al.*, 1974).

$$\text{Second law efficiency} = \frac{\text{Minimum energy required to perform task}}{\text{Actual energy used to perform task}}$$

The minimum amount of energy required to perform a task is prescribed by the second law of thermodynamics. Carnahan *et al.* estimated the second law efficiency for electric water heating in households in the USA as 1.5%. Most electricity in the United States is generated in thermal plants with an average first law efficiency of 33%. Because most electricity in New Zealand is generated in hydro plants, second law efficiency for electric water heating in New Zealand would be of the order of 5%.

There is still a 20-fold difference between the actual and the ideal showing that there is enormous potential for reducing water heating energy use. In fact, this low second law efficiency reflects the squandering, thermodynamically speaking, of our highest

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3 "Additional" Type III accounts (see Chapter 12) provide a comprehensive framework for this kind of information.

4 The "laws" referred to are the first and second laws of thermodynamics. For a readable explanation of second law efficiency, see Meier *et al.*, 1983, Chapter 1.

quality form of energy on a very low quality task, that of raising water temperature a few degrees above ambient.[5]

Thus, the resource of conserved energy lying in the end use of household electric water heating (in the year 2000) is 95% of 4.7 TWh per year, that is, about 4.5 TWh per year.

How much of this 4.5 TWh per year is both technically and economically recoverable and can, therefore, be classed as reserves? The identification of reserves of conserved energy is, in fact, the objective of the "supply curves of conserved energy" methodology referred to above. Each reserve can be tapped by a particular conservation measure as shown in the Type Ia account in Table 9.1. Instead of having names like the Kapuni gas field or the Luggate dam, reserves of conserved energy have names like "New water heaters insulated with 55 mm polyurethane".

Table 9.1 A Type Ia account. Reserves of conserved water heating electricity in households in New Zealand. 2000.

Reserve	GWh/yr
Turn thermostat down 15°C	334
New water heaters insulated with 55 mm polyurethane	87
Retrofit water heaters with fibreglass	32
New water heaters insulated with 100 mm polyurethane	21
Solar pre-heating	1980
Total	2454

Source: Adapted from Wright & Baines, 1986.

Notes:

1. The conservation measures are incremental; insulation with 100 mm of polyurethane does not save less energy than insulation with 55 mm of polyurethane. Hence, the energy savings are additive.
2. The last reserve should perhaps more properly be called a reserve of solar energy. However, there is no difference between conserved energy and solar energy in economic terms; both reduce the demand for commercial energy by means of investment in end use equipment. However, because there is a new source of energy, the second law constraint is removed.

The separation of "economic" reserves from the larger resource can be done using a standard investment analysis. In Table 9.1, a kWh of conserved electricity has been classed "economic" if it costs less than six cents (1985 dollars) from a "national" perspective (essentially the perspective of the generating authority).

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[5] It is customary to think of electric water heating as being 100% efficient, and so it is, in first law terms. However, the fact that a heat pump can do the job using a third of the electricity of a resistance water heater indicates that first law efficiencies are an inadequate indicator of conservation potential.

Table 9.1 shows the reserves of conserved energy in household water heating electricity to be 2.5 TWh per year, about half of the total resource of 4.5 TWh per year.

9.3 Type Ib accounts for conserved energy

Theoretically, there is no reason why Type Ib accounts for conserved energy could not be compiled. "Extraction" of the reserve occurs as efficiency measures are adopted. "New reserves" of conserved energy are "discovered" with technological innovations. "Re-evaluation" of existing reserves of conserved energy can occur for many reasons. More resource will become reserve if, for instance, the price of conventional fuels rises or widespread adoption of conservation technologies drives their price down through economies of scale.

However, there are a great many practical obstacles to the preparation of Type Ib accounts for conserved energy. Extraction of conserved energy is revealed by reductions in demand, or at least by reductions in the rate of increase in demand. But the "ground" shifts constantly at the demand end; a decrease in demand may be partly due to increased efficiency of use and partly due to a lowered standard of living. Further, because conserved energy cannot be instantly extracted, estimates of the potential for conservation must be based on forecasted demand. Thus, what is attributed to extraction of conserved energy could be partly inaccuracy in forecasting.

One major reason for the slow acceptance of conserved energy as *bona fide* energy supply is that it is such a dispersed resource. This makes data collection particularly difficult, especially since there is such a lack of the end use information necessary for a base. Annual updating of the kind needed for a Type Ib account would be impractical; any effort invested in Type I accounts for conserved energy should go into Type Ia accounts.

The real value of Type Ib accounts lies in the automatic check for internal consistency; a Type Ib account must balance. This principle of internal consistency must form the foundation of any studies of reserves of conserved energy. In the past, some studies have been done where estimates of conserved energy available from a particular end use exceed the total amount of energy used by that end use, because the principle of internal consistency has not been applied.

Summary of Chapter 9

Conserved energy is a valid energy supply. Reserves accounts for conserved energy should be prepared along with other energy accounts.

Resources of conserved energy can be identified by applying the second law of thermodynamics to the end uses of energy.

Type Ia accounts for some reserves of conserved energy can be prepared from studies of the technical and economic potential for energy efficiency improvements.

Type Ib accounts would be frustrating, if not impossible, to prepare for conserved energy. Effort in this area would be better directed toward a complete set of Type Ia accounts.

10 Extraction, conversion and trade accounts

10.1 Norwegian examples

Table 10.1 is an example of a Type IIa account where the intent is to trace flows of direct energy through the economy. The last section of this account is focused on consumption so this Type II account contains some Type III (consumption) information. The matching of sales of different fuels with that estimated from extraction, conversion and trade data constitutes the balance. In this case, the discrepancy is 34 PJ overall with almost all of it occurring in the electricity sector (presumably, due mostly to transmission and distribution losses). The term "use of energy" includes energy used as raw materials. Another version of this account giving more detail on the different energy industries can be found in the same publication (Central Bureau of Statistics, 1981, pp.46-47).

Table 10.1 A Type IIa account. Extraction, conversion and direct use of energy. Norway. 1978. PJ.

	Total	Coal	Coke[1]	Fuel wood	Crude oil	Nat-ural gas	Refin -ery prod.[1]	Elec tri-city
Extraction of energy	1562	11	-	-	717	542	-	291
Energy use in extraction sectors	-30	-	-	-	-	-23	-3	-4
Imports[2]	778	13	25	0	336	-	400	3
Exports[3]	-1335	-2	-8	0	-706	-520	-84	-15
Stocks (+ decrease, - increase)	10	2	2	-	-1	-	7	
Primary supply	984	23	19	0	347	-1	320	275
Petroleum refineries	-19	-	4	-	-349	-	326	-1
Other energy sectors, other supply	6	-12	10	10	-	-	-3	0
Registered losses, statistical errors	-34	-1	0	-	1	1	-7	-27
Use outside energy sectors	937	10	33	10	-	-	636	248
Agriculture & fishing	31	-	-	-	-	-	28	2
Energy intensive manufacturing	172	7	28	-	-	-	42	95
Other manufacturing & mining	113	3	4	2	-	-	66	37
Ocean transport	297	-	-	-	-	-	297	-
Other industries	163	-	-	-	-	-	124	39
Private households	162	0	1	8	-	-	78	75

Source: Central Bureau of Statistics, 1981, p.53.
Notes:
1. Coke includes petrol coke. Refining products include liquefied gas.
2. Includes direct purchases abroad.
3. Includes foreign purchases in Norway.

Table 10.2 is an example of a Type IIb account where the intent is to trace all flows of energy (indirect as well as direct) through the economy. Again this account includes some Type III (consumption) information, but in a different form. In Table 10.2, the term "energy goods" is used to mean direct energy, that is, energy that is sold as one fuel or another. Thus, "import of energy goods" in this table is the same as "imports" in Table 10.1.

From Table 10.2, it can be seen, for instance, that in 1978 Norway exported more energy embodied in various commodities than it imported.

Table 10.2 A Type IIb account. Direct and indirect energy use. Norway. 1978. PJ.

	Total	Solid fuels	Oil & gas	Electricity
Extraction of energy	1562	11	1260	291
Import of energy goods	778	38	736	3
Export of energy goods	-1335	-10	-1310	-15
Stocks of energy goods (+ decrease, - increase)	10	4	6	
Energy use in Norwegian industries & households	1014	43	693	279
Indirect import of energy	445	101	188	157
Indirect export of energy	-773	-86	-501	-185
Indirect energy, stock change (+ decrease, - increase)	21	12	-6	12
Energy in domestic final deliveries	707	70	374	263
Energy for:				
Private consumption	437	25	244	168
Public consumption	58	3	34	21
Investments	212	42	96	74

Source: Central Bureau of Statistics, 1981, p.57.
Note: The changes in stocks of indirect energy include statistical errors.

10.2 A Type IIa account for New Zealand

Type IIa accounts appear very similar to what is conventionally called an energy balance. An energy balance is now published regularly in the Energy Data File in New Zealand and is known as the Energy Matrix. (The Energy Matrix has already been discussed in Chapter 3 as the main outcome of the *"Review of energy and mining statistics"* (Department of Statistics, 1983).) Table 10.3 is the 1989 Energy Matrix modified somewhat to look more like Table 10.1.

Table 10.3 A Type IIa account for New Zealand. Extraction, conversion and direct use of energy. Year ended June 1990. PJ.

	Solid fuels	Gas	Hydro	Geo-thermal	Elec-tricity	Crudes	LPG/ NGL	Refine prod.	Total
Extraction of energy	83.1	187.4	73.6	84.2		80.5	5.7		514.6
Imports	0	0				144.8		17.1	161.9
Exports	11.0	0				27.6		20.6	59.2
Stock change	1.8	0.3				-2.6		5.8	5.3
International transport								31.3	31.3
Primary supply	70.3	187.1	73.6	84.2		200.3	5.7	-40.5	580.7
Electricity generation	7.5	67.1	73.6	68.4				0.3	216.7
Petrol production	0	56.7				200.3			257.0
Gas manufacture	0.2	0.8							1.0
Losses & own use	3.6	2.2		6.0	9.7		0.6	-0.3	21.8
Non-energy use	0	18.0						8.7	26.7
Secondary production	0	0.1			102.7			205.4	308.2
Consumer energy (calc.)	59.1	42.5		9.8	93.0		5.2	156.3	365.8
Error	-2.1	-3.5		0	0		-0.4	2.0	-4.0
Consumer energy (obs.)	61.1	46.0		9.8	93.0		5.6	154.3	369.8
Use outside energy sectors:									
Industrial	47.6	32.3		7.2	39.8		2.0	9.79	138.6
Commercial/agriculture	3.3	5.8		2.6	18.9			20.7	51.3
Domestic	10.1	5.0			34.2		0.7	0.1	50.1
Transport	0.1	2.9			0.2		2.9	123.7	129.7

Source: Adapted from Ministry of Commerce, 1991, p.48.

Notes:

1. Primary supply = Extraction of energy + Imports - Exports - Stock change - International transport.
2. In calculating the electricity generated from thermal power plants, efficiencies of 33% for gas plants, 30% for coal plants and 10% for geothermal plants have been used.
3. Consumer energy (calculated) = Primary supply - Electricity generation - Petrol production - Gas manufacture - Loss & own use - Non-energy use + Secondary production.

Clearly, there is plenty of "extraction, conversion and trade" information in this country although there is room for improvement in the presentation of the Energy Matrix. For a start, it contains so much data and is in such small print that actually using the Matrix is very hard on the eyes; a simpler version as in Table 10.3 may have merit. The number of significant figures (up to six) also makes the Matrix difficult to read and implies a level of accuracy that cannot exist. For this reason, the numbers in Table 10.3 have been rounded off to the nearest 0.1 PJ. Also, some columns have been combined. The splitting of coal into bituminous and lignite seems rather pointless as does a separate column for the tiny residue of manufactured gas. On the other hand, useful detail on refinery products has been lost by combining the columns for petrol, diesel, fuel oil, aviation fuel and other liquids, although this disaggregation does appear elsewhere in the Energy Data File.

10.3 A Type IIb account for New Zealand

Apart from the energy embodied in imports, a Type IIb account for New Zealand can be easily produced from input/output energy data. Table 10.4 is an incomplete Type IIb account that has been produced from the 1981/82 energy input-output tables.

Table 10.4 An incomplete Type IIb account for New Zealand. Year ended March 1982. PJ.

	Total	Coal	Gas	Oil	Electricity
Extraction of energy	203	53	76	0	74
Imports of energy goods	144	0	0	144	0
Exports of energy goods	-16	-5	0	-11	0
Stocks of energy goods	8	-3	0	11	0
NZ domestic energy use	339	45	76	144	74
Indirect import of energy	?	?	?	?	?
Indirect export of energy	-91	-17	-18	-42	-14
Stocks of indirect energy	-10	-1	-2	-5	-2
Energy in domestic final deliveries					
Energy for:					
Private consumption	209	19	43	97	50
Public consumption	21	7	4	7	3
Investments	32	6	8	11	7

Source: Adapted from Baines and Peet (1989).
Note: This account is not compatible with Table 10.3.

The background and experience do exist in New Zealand for estimating the energy embodied in imports; this exercise was done in the energy analysis of the 1971/72 Inter-Industry Study (Baines *et al.*, 1987). However, there are some methodological and practical problems in obtaining these data.

Firstly, what energy intensities of manufacture are to be used - the country where the imported goods were manufactured or New Zealand? The answer to this depends on the policy question being pursued. If the country of origin is chosen, obtaining the relevant information can be difficult. For the analysis of 1971/72 data referred to above, the energy intensities of production for Britain, the United States and Australia were found. The energy used in transporting goods to New Zealand should also be estimated. If New Zealand is chosen, many imported goods have never been manufactured here and so there is no record of energy use.

Summary of Chapter 10

The Energy Matrix published in the Energy Data File is a Type IIa account.

Apart from the energy embodied in imported goods, a Type IIb account can be produced for years for which energy input-output tables (based on the Inter-Industry Studies) have been prepared.

There are methodological and practical problems in assessing the energy embodied in imported goods.

11 Main consumption accounts

11.1 Norwegian examples

The main Type III accounts present consumption by economic sector. There are two kinds of these accounts: Type IIIa (Table 11.1) and Type IIIb (Table 11.2).

In Table 11.1, the direct consumption of fuels and electricity by industry and households is shown. The fuels and electricity are termed "energy goods" and are given in the units in which they are sold - tonnes of coal, GWh of electricity, and so on. Thus, a Type IIIa account gives mostly intermediate consumption, that is, the energy used by industries for the purpose of producing goods and services.

Table 11.1 is intended to be illustrative and is, in fact, only part of the Norwegian Type IIIa consumption account for 1978. In this sample, only the first sector (agriculture, forestry and fishing) is shown in a disaggregated form. However, in the full account, considerably more detail is given on the production sectors; for instance, the third sector, manufacturing, is disaggregated into 16 subsectors. Thus, in the full account, one can see, for example, that 12,365 GWh of electricity was consumed in the manufacture of primary aluminium in 1978 (18% of the total).[1]

Table 11.2 is (part of) a Type IIIb account where indirect or embodied energy is included as well as direct energy. The focus is on the final demand for goods and services. Some of these final goods and services are mostly energy goods, for example, the electricity consumed by households and the crude oil and natural gas exported. However, all final deliveries of goods and services have energy embodied in them.

Final demand in Table 11.2 is broken down into the traditional categories used in Inter-Industry Studies - household consumption (private consumption), consumption by government services (public consumption), gross fixed capital formation (investment) and exports.[2]

Like Table 11.1, Table 11.2 is not a complete consumption account. The public consumption and investment sections are complete but the other sections contain only a sample of the original.

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[1] Aluminium smelting is of considerable public interest because of the industry's high electricity consumption and low unit cost in Norway as is in New Zealand.

[2] The Inter-Industry Studies have another final demand category - "increase in stocks".

Table 11.1 A Type IIIa account. Use of energy goods outside the energy sectors, by industry in Norway. 1978.

	Coal	Coke	Fuel wood	Liquified gas	Motor spirits	Kerosene	Gas & diesel oils	Heavy fuel oil	Elec- tricity
	1000 t	1000 t	1000 m^3	1000 t	1000 t	1000 t	1000 t	1000 t	GWh
Total	356	1089	1226	329	1647	853	4759	7399	68986
Production sectors, enterprises									
1 Agriculture, forestry and fishing	-	-	-	-	20	3	608	37	652
11 Agriculture	-	-	-	-	12	1	153	37	652
12 Forestry	-	-	-	-	3	-	10	-	-
13 Fishing	-	-	-	-	5	2	445	-	-
2 Mining	-	-	-	-	1	1	40	40	840
3 Manufacturing	346	1070	226	324	249	-	495	1382	35841
5 Construction	-	-	-	-	9	1	285	1	612
6 Wholesale and retail trade, restaurants and hotels	-	-	-	-	235	10	263	14	3600
7 Transport, storage and communication	-	-	-	-	76	427	2112	5897	1076
8 Financing, insurance, real estate and business services	-	-	-	-	38	-	34	-	502
9 Other services	-	-	-	-	49	3	113	13	970
Production sectors, public services	-	-	-	-	78	4	328	2	3952
Private households	10	19	1000	5	892	403	480	13	20941

Source: Adapted from Central Bureau of Statistics, 1981, pp. 48-51.

Table 11.2 An incomplete Type IIIb account. Direct and indirect energy use in final deliveries in Norway. 1978.

	Energy use				Import share, indirect energy	Energy intensity
	Solid fuel PJ	Oil & gas PJ	Elec-tricity PJ	Total PJ	%	TJ/ mill. kr.
Private consumption, total	24.7	244.5	167.6	436.7	31	3.8
Bread, cereals etc.	0.1	2.8	1.5	4.4	32	2.1
Meat, fish etc.	0.5	10.6	4.6	15.5	22	1.8
Clothing and footwear	1.3	13.6	6.5	21.5	69	2.2
Electricity	0.4	2.0	90.9	93.3	1	23.0
Furniture and household equipment	3.2	12.7	8.7	24.5	70	2.6
Purchase of cars etc.	2.8	6.6	5.6	15.1	77	2.3
etc.						
Public consumption, total	2.9	34.1	20.6	57.6	24	1.5
Public administration	0.5	6.7	3.1	10.2	36	1.1
Education and research	0.5	8.9	7.7	17.0	20	1.4
Health and veterinary services	0.4	5.4	4.4	10.1	23	1.4
Other public services	1.6	13.2	5.5	20.3	21	2.0
Investment, total	42.2	96.0	74.2	212.2	65	3.0
Buildings and constructions	17.1	46.4	29.7	93.1	46	2.8
Investments in oil and gas production	6.6	17.5	10.1	34.3	74	3.6
Ships	7.2	9.2	11.6	28.0	83	3.7
Other means of transportation	2.2	4.1	4.3	10.6	85	2.2
Machinery, tools etc.	9.2	18.7	18.4	46.3	80	3.1
Export, total	96.2	1802	200.7	2099.9	8	26.2
Crude oil and natural gas	0.4	1253.0	0.9	1254.3	0	92.2
Paper and paperboard	0.6	12.8	7.7	21.1	23	10.4
Plastic and artificial fibres	1.4	4.3	2.5	8.1	51	12.3
Iron and steel	6.2	1.7	6.1	14.0	24	13.6
Aluminium	18.6	11.1	55.9	85.5	31	23.0
Electricity	0.0	0.2	16.4	16.6	0	71.1
etc.						

Source: Adapted from Central Bureau of Statistics, 1981, pp. 58-59.
Note: Foreign purchases in Norway are not included.

11.2 A Type IIIa account for New Zealand

All the Type III accounts produced for New Zealand in this publication have been compiled using the extensive work done on the energy input-output analyses of the New Zealand economy.[3] Some of the consumption accounts can be assembled more directly from this work than others. The energy input-output analyses rest on the Inter-Industry Studies; in New Zealand these are carried out only every five years, which would appear to make annually updated consumption accounts, as produced in Norway, more difficult to achieve in New Zealand and prone to greater uncertainty. There are, however, methods for "updating" input output analyses in years between Inter-Industry Studies.

A consumption account for direct energy is really the kind of exercise that happens as a preliminary step to identifying the energy transactions required for an energy input-output analysis. Such an exercise is necessarily "messy" in this country because there is no single census or survey that regularly provides this information systematically across all sectors of the New Zealand economy.

Historically, it has been possible to gather this information in New Zealand from a variety of statistical sources. The main inadequacies have been:
- the lack of comprehensive coverage across all sectors,
- inconsistency in sectoral aggregations for the various data sources,
- the lack of continuity of data gathering,
- that data for different sectors has sometimes been collected in different years, and
- the inability to check internal consistency because of partial coverage.

The Economy-wide Census carried out in 1986/87 appeared to promise a "tidier" exercise. This census brought data-gathering across all economic sectors into a single consistent time period and provided more detailed information on the purchases (and quantities) of energy goods by industry sectors. Unfortunately, the same set of questions was not applied consistently across all industry sectors; questions covering the physical detail of fuel and electricity purchases were addressed to only some sectors - the manufacturing sectors, the transport sector and some wholesale and retail trade sectors. Consequently, there is no feedback path for checking internal consistency for the economy as a whole.

Even more unfortunately, in the next Economy-wide Census, scheduled to be undertaken in 1992, it is almost certain that not even these sectors will be questioned on their purchases of energy goods (in physical units). Without such data, it is very difficult to identify rigorously any trends in energy productivity or physical efficiency

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[3] Chapter 9 in Wright (1990) contains a brief description of the New Zealand energy input-output analysis by Baines, Peet and others.

at an aggregate level. Further, the physical quantities of different fuels consumed by various sectors are the basic statistical data for estimating fossil fuel-related emissions. It is, of course, possible to derive energy use in physical units from data on expenditure using tariff information, but this is not so accurate; the more "derived" the data are, the greater the lack of confidence in the information.

Data from the 1986/87 Economy-wide Census have been used to compile part of a Type IIIa account for New Zealand. Table 11.3 shows the consumption of various fuels in physical units for some sectors.

Table 11.3 An incomplete Type IIIa account for New Zealand. Use of energy goods outside the energy sectors in 1986/87.

NZSIC sector		Electricity GWh	Coal 1000 t	Petrol Mlitres	Diesel Mlitres	CNG 1000 t	Gas PJ
Total Manufacturing		8441	359	145	163	9	73
3111	Meat processing	559	61	3	5	0	4
3112	Dairy products	270	88	9	9	4	43
3113/3114	Fruit & vegetable/fish processing	161	2	3	6	0	1
3115/3122	Oils, grains, baking, sugar, misc.food, animal feeds	206	4	47	83	1	3
32	Textile, apparel & leathergoods	283	23	10	6	1	3
33	Wood processing, wood product manufacture	340	0	9	14	0	2
34	Paper & paper products, printing & publishing	1163	23	9	5	0	6
351	Industrial chemicals	144	0	3	2	0	3
352	Other chemical products	54	0	6	2	1	1
353	Petroleum refineries	98	0	2	1	0	0
354	Miscellaneous products of petroleum & coal	5	0	0	2	0	0
356	Plastic products n.e.c.	143	0	3	0	0	0
36	Concrete, clay, glass etc. & related mineral products	242	40	4	16	0	3
371	Iron & steel	372	114	2	1	0	1
372	Non-ferrous metal	3816	0	2	1	1	0
381	Fabricated metal products	195	0	12	3	1	3
382	Machinery (excl. electrical)	115	0	10	3	0	0
383	Electrical machinery	105	1	5	2	0	0
384	Transport equipment	142	1	4	2	0	1
385	Professional & scientific equipment	7	0	1	0	0	0
39	Other manufacturing industries	21	0	2	0	0	0

Source: Adapted from Department of Statistics (1987).

11.3 A Type IIIb account for New Zealand

A Type IIIb account can be readily derived from the energy input-output analyses. The input-output energy tables for 1981/82 have been used to produce Table 11.4. Unlike the Type IIIb account for Norway in Table 11.2, Table 11.4 does not contain a column for the indirect energy component of imported goods. (See Section 10.3.)

Table 11.4 A Type IIIb account for New Zealand. Direct and indirect energy use in final deliveries in 1981/82. PJ.

	Energy use					Energy
	Coal	Gas	Oil	Electricity	Total	intensity MJ/$
Private consumption, total	18.6	42.6	97.1	49.9	208.1	
Coal mining	5.7	0.0	0.0	0.0	5.7	*1.03
Natural gas & condensate	0.0	0.4	0.0	0.0	0.4	*1.14
Petroleum products	0.0	8.8	65.9	0.0	74.7	*1.08
Electricity	1.8	11.6	0.3	33.9	47.6	*1.49
Manufactured gas	0.2	3.3	0.1	0.0	3.6	*1.23
Agriculture	0.2	0.5	1.2	0.4	2.3	5.1
Fishing & hunting	0.0	0.1	0.8	0.0	1.0	18.6
Forestry & logging	0.0	0.0	0.1	0.0	0.1	10.1
Food, beverages & tobacco	4.1	3.7	6.1	2.6	16.6	10.0
Textiles	0.8	1.5	2.0	0.9	5.2	5.3
Wood	0.1	0.5	0.6	0.5	1.6	7.7
Paper	0.5	1.1	0.9	1.2	3.6	13.6
Chemicals	0.4	0.8	0.9	0.4	2.5	6.5
Non-metallic minerals	0.5	0.1	0.1	0.1	0.8	20.6
Basic metals	0.0	0.0	0.0	0.1	0.1	28.3
Fabricated metal products	0.6	1.3	1.1	1.4	4.5	4.9
Other manufacturing	0.1	0.1	0.1	0.2	0.5	5.9
Construction	0.0	0.0	0.0	0.0	0.1	5.9
Trade, restaurants, h/motels	1.3	3.8	6.5	3.8	15.3	4.5
Transport & storage	0.1	1.0	4.6	0.4	6.1	13.6
Communications	0.0	0.1	0.3	0.1	0.6	2.3
Financing, insurance, etc.	0.2	0.5	0.7	0.6	1.9	2.8
Owner-occupied dwellings	0.8	0.9	1.1	0.8	3.6	2.3
Community,social etc. serv.	0.8	1.7	2.7	1.8	6.9	6.4
Central government services	0.1	0.0	0.1	0.0	0.2	3.9
Local government services	0.0	0.0	0.1	0.0	0.2	6.5
PNP services	0.2	0.7	0.8	0.6	2.3	5.4
Public consumption, total	6.7	4.4	6.9	3.6	21.6	
Transport & storage	0.0	0.2	0.9	0.1	1.2	13.6
Central government services	6.3	3.2	4.3	2.8	16.7	3.9
Local government services	0.3	0.9	1.6	0.8	3.7	6.5

Table 11.4 continued.

	Energy use					Energy
	Coal	Gas	Oil	Elec-tricity	Total	intensity MJ/$
Investment, total	6.2	7.5	10.5	7.4	31.5	
Food, beverages & tobacco	0.0	0.0	0.1	0.0	0.2	10.0
Textiles	0.0	0.0	0.0	0.0	0.1	5.3
Wood	0.1	0.2	0.2	0.2	0.7	7.7
Paper	0.0	0.0	0.0	0.1	0.2	13.6
Chemicals	0.0	0.0	0.0	0.0	0.1	6.5
Non-metallic minerals	0.1	0.0	0.0	0.0	0.2	20.6
Basic metals	0.0	0.0	0.0	0.1	0.2	28.3
Fabricated metal products	1.0	2.0	1.8	2.3	7.1	4.9
Construction	4.6	4.2	6.7	3.8	19.4	5.9
Trade, restaurants, h/motels	0.2	0.7	1.2	0.7	2.7	4.5
Transport & storage	0.0	0.0	0.1	0.0	0.1	13.6
Financing, insurance etc.	0.0	0.1	0.1	0.1	0.3	2.8
Local government services	0.0	0.0	0.1	0.0	0.1	6.5
Exports, total	17.1	18.3	41.9	14.5	91.8	
Coal mining	5.0	0.0	0.0	0.0	5.0	*1.03
Natural gas & condensate	0.0	0.1	0.0	0.0	0.1	*1.14
Petroleum products	0.0	1.5	11.0	0.0	12.4	*1.08
Electricity	0.0	0.0	0.0	0.0	0.0	*1.49
Manufactured gas	0.0	0.1	0.0	0.0	0.1	*1.23
Agriculture	0.2	0.5	1.2	0.4	2.3	5.1
Fishing & hunting	0.0	0.2	1.4	0.0	1.7	18.6
Forestry & logging	0.0	0.0	0.2	0.0	0.3	10.1
Mining & quarrying	0.1	0.1	0.1	0.1	0.3	13.3
Food, beverages & tobacco	7.4	6.7	10.9	4.8	29.8	10.0
Textiles	0.7	1.2	1.6	0.7	4.2	5.3
Wood	0.1	0.3	0.4	0.3	1.0	7.7
Paper	0.6	1.4	1.1	1.5	4.6	13.6
Chemicals	0.1	0.3	0.3	0.1	0.8	6.5
Non-metallic minerals	0.4	0.1	0.1	0.1	0.7	20.6
Basic metals	1.4	1.8	0.6	3.8	7.6	28.3
Fabricated metal products	0.2	0.4	0.4	0.5	1.5	4.9
Other manufacturing	0.0	0.0	0.0	0.1	0.1	5.9
Construction	0.0	0.0	0.1	0.0	0.2	5.9
Trade, restaurants, h/motels	0.4	1.1	1.9	1.1	4.4	4.5
Transport & storage	0.3	2.1	10.3	0.8	13.5	13.6
Communication	0.0	0.0	0.0	0.0	0.1	2.3
Financing, insurance etc.	0.0	0.1	0.2	0.1	0.5	2.8
Community, social etc. serv.	0.0	0.0	0.1	0.0	0.2	6.4
Central Government services	0.0	0.0	0.0	0.0	0.1	3.9

Source: Adapted from Baines and Peet (1989).
Note: * denotes that the energy intensities for the outputs of the five energy sectors are given in MJ/MJ.

Summary of Chapter 11

An incomplete Type IIIa account has been prepared. It is incomplete because it is based on the last Economy-wide Census, in which all sectors were not asked the same set of energy questions.

Type IIIb accounts are easily prepared from the energy input-output analyses. As for Type IIb accounts, the energy embodied in imported goods is omitted.

12 Additional consumption accounts

12.1 Norwegian examples

In the additional Type III accounts the focus is on consumption by purpose or end use. Two examples of additional Type III accounts are given below. These two form a pair; Table 12.1 shows energy use by aggregated economic sector and purpose, and Table 12.2 shows energy use by fuel source and purpose.

Table 12.1 An additional Type III account. Use of energy outside the energy sectors, by sector and purpose in Norway. 1978. PJ.

<table>
<tr><th>Purpose (end use category)</th><th>Total</th><th>Agri-culture fishing</th><th>Mining quarrying manufact.</th><th>Other industries</th><th>House-holds</th></tr>
<tr><td>Total energy</td><td>937</td><td>31</td><td>285</td><td>460</td><td>162</td></tr>
<tr><td>Feedstocks and reduction purposes</td><td>72</td><td>-</td><td>72</td><td>-</td><td>-</td></tr>
<tr><td>Feedstocks</td><td>37</td><td>-</td><td>37</td><td>-</td><td>-</td></tr>
<tr><td>Means of reduction</td><td>35</td><td>-</td><td>35</td><td>-</td><td>-</td></tr>
<tr><td>Transport</td><td>464</td><td>23</td><td>7</td><td>394</td><td>40</td></tr>
<tr><td>Ocean transport</td><td>297</td><td>-</td><td>-</td><td>297</td><td>-</td></tr>
<tr><td>Other transport and mobile machines</td><td>167</td><td>23</td><td>7</td><td>97</td><td>40</td></tr>
<tr><td>Electricity specific purposes</td><td>117</td><td>2</td><td>91</td><td>10</td><td>14</td></tr>
<tr><td>Electrolysis</td><td>53</td><td>-</td><td>53</td><td>-</td><td>-</td></tr>
<tr><td>Lighting</td><td rowspan="2">64</td><td rowspan="2">2</td><td>6</td><td rowspan="2">10</td><td>4</td></tr>
<tr><td>Stationary machinery</td><td>32</td><td>10</td></tr>
<tr><td>Heat</td><td>284</td><td>5</td><td>115</td><td>56</td><td>108</td></tr>
<tr><td>Process heat >600°C</td><td>57</td><td>-</td><td>57</td><td>-</td><td>-</td></tr>
<tr><td>Process heat 200-600°C</td><td>0</td><td>-</td><td>0</td><td>-</td><td>-</td></tr>
<tr><td>Process heat 100-199°C</td><td>47</td><td>-</td><td>41</td><td>3</td><td>3</td></tr>
<tr><td>Hot water <100°C</td><td rowspan="2">180</td><td rowspan="2">5</td><td rowspan="2">17</td><td>7</td><td>25</td></tr>
<tr><td>Room heating</td><td>46</td><td>80</td></tr>
</table>

Source: Central Bureau of Statistics, 1981, p.63.

Table 12.2 **An additional Type III account. Use of energy outside the energy sectors, by fuel and purpose in Norway. 1978. PJ.**

Purpose (end use category)	Total	Solid fuels	Oil	Electricity
Total energy	937	53	636	248
Feedstocks and reduction purposes	72	41	31	-
Feedstocks	37	6	31	-
Means of reduction	35	35	-	-
Transport	464	-	462	2
Ocean transport	297	-	297	-
Other transport and mobile machines	167	-	165	2
Electricity specific purposes	117	-	-	117
Electrolysis	53	-	-	53
Lighting, stationary machinery etc.	64	-	-	64
Heat	284	12	143	129
Process heat >600°C	57	1	24	32
Process heat 200-600°C	0	-	0	-
Process heat 100-199°C	47	1	36	10
Hot water and room heating	180	10	83	87

Source: Central Bureau of Statistics, 1981, p.64.

12.2 Additional Type III accounts for New Zealand

Attempts have been made to prepare these types of energy accounts in New Zealand in the past, for instance, in the NZERDC work on energy scenarios. As with the main Type III accounts, the raw data necessary to prepare such accounts properly are not collected in any systematic manner.

Tables 12.3 and 12.4 are New Zealand versions of the Norwegian accounts above. The data in these tables are based largely on informed guesstimates, supplemented by detailed analyses in a few sectors and what amounts to anecdotal information in other *ad hoc* reports[1]. Consequently, these New Zealand additional Type III accounts do not have the same level of detail as the Norwegian examples. (Table 12.3 could be presented in a more disaggregated form since it has been prepared from data/estimates at the 25-sector level. However, the level of accuracy implied by such disaggregation would be an illusion.)

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1 Estimates are inferred from work where the main objective was other than an analysis of energy consumption by end use.

Table 12.3 An additional Type III account for New Zealand. Use of energy outside the energy sectors, by sector and purpose. 1981/82. PJ.

	Total	Agric. Fishing Forest.	Mining Quarry Manuf.	Other indust.	House-holds
Total energy	283.5	16.7	88.0	77.4	101.4
Feedstocks	18.7	0.0	18.7	0.0	0.0
Motive power	130.6	13.6	7.0	47.5	62.4
High temperature heat	32.5	0.3	28.5	1.2	2.5
Low temperature heat	65.6	1.4	18.2	17.0	29.0
Miscellaneous electrical	36.0	1.4	15.5	11.7	7.4

Source: Adapted from internal working data for input-output energy analysis.

Table 12.4 An additional Type III account for New Zealand. Use of energy outside the energy sectors, by fuel and purpose. 1981/82. PJ.

	Total	Coal	Oil	Gas	Elec-tricity
Total energy	283.5	37.8	152.3	21.2	72.2
Feedstocks	18.7	9.2	0.5	0.0	9.0
Motive power	130.6	0.0	129.3	1.0	0.3
High temperature heat	32.5	10.6	10.7	8.2	3.0
Low temperature heat	65.6	18.0	9.8	12.0	25.8
Miscellaneous electrical	36.0	0.0	2.0	0.0	34.0

Source: Adapted from internal working data for input-output energy analysis.

There is a growing interest in New Zealand in the reduction of demand as a valid form of energy supply as discussed in Chapter 9. Estimates of potential supply through energy conservation rest on end use analyses, which are, in fact, additional Type III accounts. Examples of consumption accounts being used for this purpose can be found in Wright and Baines (1986) and Cameron (1989).

Summary of Chapter 12

Additional Type III accounts can be prepared from the energy input-output analyses giving consumption by sector and purpose and by fuel and purpose.

The data in these accounts are aggregated and are of mixed quality.

13 Emissions accounts for energy-related pollutants

13.1 Norwegian examples

The pollutants produced by the use of energy are currently of greater public interest than the depletion of energy reserves both in Norway and in New Zealand. The Type III energy accounts have been the basis for compiling "emissions accounts" for energy-related pollutants in Norway. These accounts, which detail the emission of various pollutants by various sectors of the economy, can be used in models for developing strategies for achieving environmental goals.

Emissions accounts have been compiled for a number of energy-related air pollutants in Norway, including carbon dioxide, sulphur dioxide and nitrogen oxides. Of these, accounts for carbon dioxide would seem to be most relevant in New Zealand at present because of the Government target of a 20% reduction in 1990 carbon dioxide emission by the year 2000.

Three carbon dioxide emissions accounts for Norway are presented here. The first gives carbon dioxide emissions by economic sector and the second, by source. A third account again gives emissions of carbon dioxide by sector but this time expressed in units of tonnes per person-year and tonnes per 100,000 Norwegian kroner of gross production. Such information would be useful in reconciling environmental targets, employment targets and economic growth targets.

Table 13.1 Emissions of carbon dioxide by sectors. Norway. 1985. 1000 tonnes.

Sector	Carbon dioxide	
Total		33287
Agriculture		828
Fishing, sealing and whaling		1363
Manufacturing, mining and quarrying		11093
Pulp and paper	525	
Energy intensive manufacturing, petroleum refining	8903	
Other manufacturing and mining	1665	
Oil extraction and oil well-drilling		4337
Construction		566
Trade, services		3020
Transport		6611
Ocean transport	912	
Aviation	1700	
Coastal water transport	2500	
Road transport	1499	
Households		5469

Source: Adapted from Central Bureau of Statistics, 1988, p.164.

Table 13.2 Emissions of carbon dioxide by source. Norway. 1985. 1000 tonnes.

Source		Carbon dioxide	
Total			33287
Stationary combustion			12600
Industrial combustion		9161	
Other combustion		3439	
Industrial processes			5518
Industrial chemicals		478	
Mineral products		1048	
Metal production		3992	
Mobile sources			14999
Light vehicles:	- petrol	4600	
	- diesel	370	
Heavy vehicles:	- petrol	280	
	- diesel	1890	
Motorcycles, mopeds		300	
Tractors and other motor equipment		722	
Railroad		51	
Aviation		1700	
Coastal water transport		2500	
Ocean transports		912	
Fishing fleet		1357	
Oil well drilling		317	

Source: Adapted from Central Bureau of Statistics, 1988, p.165.
Note: The figures in this table do not add exactly.

Table 13.3 Emissions of carbon dioxide per person-year and per unit gross production in aggregated sectors. Norway. 1985.

Sector	tonnes CO_2 per person-year	tonnes CO_2 per 100,000 Nkr
All sectors	15	6
Agriculture	7	5
Fishing	53	37
Pulp and paper	44	16
Energy intensive manufacturing	192	71
Other manufacturing and mining	17	8
Services	3	1
Transport	40	17
Other sectors	30	3

Source: Adapted from Central Bureau of Statistics, 1988, p.166.

13.2 Carbon dioxide emissions by sector

It is a relatively straightforward exercise to compile carbon dioxide emissions by economic sector for New Zealand using the energy input-output analyses as a base.

The emissions account below (Table 13.4) is considerably more detailed than its Norwegian equivalent (Table 13.1) in that the economic sectors are not aggregated and the carbon dioxide is given by fuel source. (However, such detail must lie behind Table 13.1.) The information in Table 13.4 can also presented at another level of detail, namely a split into carbon dioxide attributable to the production of exports and carbon dioxide attributable to local consumption of goods and services.

Table 13.4 Carbon dioxide emissions from fossil fuels by economic sector in New Zealand. 1981/82. 1000 tonnes.

Sector	Industry	Coal	Gas	Oil	Total
Total		5946	5576	11881	23402
1	Coal mining	1559	0	0	1559
2	Crude petroleum & natural gas products	0	67	0	67
3	Petroleum & coal products	0	763	5338	6101
4	Electric light & power	200	855	20	1075
5	Gas manufacture and distribution	28	259	4	291
6	Agriculture	51	93	253	397
7	Fishing & hunting	3	29	178	210
8	Forestry & logging	10	32	163	205
9	Mining & quarrying	8	4	8	20
10	Food, beverages & tobacco	1344	802	1370	3516
11	Textiles, apparel & leather	180	212	290	681
12	Wood & wood products	35	84	113	233
13	Paper & paper products	129	200	172	501
14	Chemicals, rubber & plastic	70	90	111	272
15	Non-metallic minerals	123	23	22	168
16	Basic metal industries	178	156	50	384
17	Fabricated metal products	212	283	272	768
18	Other manufacturing industries	10	12	15	38
19	Construction	526	316	533	1375
20	Trade, restaurants, hotels	220	422	777	1418
21	Transport, storage	55	243	1240	1539
22	Communications	5	11	28	44
23	Financing, insurance, etc.	27	52	73	153
24	Ownership of onwer-occupied dwellings	93	65	83	241
25	Community, social & personal services	91	132	213	436
26	Central government services	726	244	345	1315
27	Local government services	43	75	140	258
28	PNP services to households	19	50	67	136
29	Domestic services of households	0	1	1	2

Source: Adapted from Baines (1991).

13.3 Carbon dioxide emissions by source

Some information on the sources of carbon dioxide in New Zealand was provided in a 1990 Ministry for the Environment report on climate change. Table 13.5 gives emissions of carbon dioxide by "sources" that do not correspond with the Norwegian concept of sources. These "sources" are essentially fuels along with a few non-combustion industrial processes that produce carbon dioxide.

Table 13.5 New Zealand's production of carbon dioxide. 1989.

Carbon dioxide source	Million tonnes CO_2 per year
Liquid fuels, oil	10.45
Electricity production	3.63
Natural gas	2.86
Synfuel	2.23
Coal and lignite	4.03
Wood fuels	1.76
Lime production	0.55
Cement production	0.55
Aluminium production	0.37
Steel production	1.24
Landfill gas	0.55
LPG	0.37
Total	26.28

Source: Ministry for the Environment, 1990, p.15.

Note: The carbon dioxide from wood fuels and landfill gas is not included in the total as it is carbon dioxide recently removed from the the atmosphere.

Table 13.6 Carbon dioxide emissions from different energy sources in New Zealand. 1981/82. 1000 tonnes.

	Total	Coal	Gas	Oil	Elect-ricity
Total	17568	4222	1563	9245	2538
Feedstocks	1377	1028	0	31	317
Motive power	7928	0	73	7845	10
High temperature heat	2546	1181	610	650	105
Low temperature heat	4400	2014	880	597	908
Miscellaneous electrical	1318	0	0	121	1197

Source: Adapted from internal working data for input-output energy analysis.

13.4 Carbon dioxide intensities of employment and production

The input-output framework has been used to analyse the links between energy consumption and employment in New Zealand industry (Baines & Peet, 1981). This resulted in tables of energy use per person-year by economic sector for 1971/72 data. This sort of exercise could be repeated to study the link between employment and carbon dioxide emissions.

Because the energy input-output tables give energy intensities of production (in MJ/$) by fuel, it is a simple exercise to translate them into tables giving the carbon dioxide intensities of production. Table 13.7 is an example.

Table 13.7 Emissions of carbon dioxide per unit gross output. New Zealand. 1981/82. Tonnes CO_2 per million dollars output.

Sector	Industry	Coal	Gas	Oil	Total
6	Agriculture	43	78	212	332
7	Fishing & hunting	18	197	1203	1419
8	Forestry & logging	38	118	595	751
9	Mining & quarrying	308	174	336	818
10	Food, beverages & tobacco	278	166	283	727
11	Textiles, apparel & leather	96	113	155	365
12	Wood & wood products	66	158	212	436
13	Paper & paper products, printing	196	304	262	762
14	Chemicals, rubber, plastics	115	148	182	446
15	Non-metallic minerals	1359	250	245	1854
16	Basic metal industries	577	504	162	1243
17	Fabricated metal products	76	102	98	276
18	Other manufacturing industries	89	107	128	323
19	Construction	157	94	159	410
20	Trade, restaurants, hotels	43	82	151	275
21	Transport, storage	36	158	807	1001
22	Communications	17	37	92	146
23	Financing, insurance, etc.	28	55	76	159
24	Ownership of owner-occupied dwellings	61	42	54	156
25	Community, social & personal services	82	118	191	391
26	Central government services	165	55	78	298
27	Local government services	68	119	223	410
28	PNP services to households	43	115	152	309
29	Domestic services of households	32	46	72	151

Adapted from Baines (1991).

The input-output data base can also be used to produce tables of CO_2 per $ of added value giving a direct link with GDP. An example is given in Baines (1991).

Summary of Chapter 13

Type III energy accounts can be used to produce emissions accounts for energy-related pollutants.

Emissions accounts show how much of a particular pollutant is produced by each economic sector.

Several emissions accounts for carbon dioxide have been produced.

14 Conclusions and recommendations

Recommendation 1:

The Ministry for the Environment should clarify its role in energy policy in order to identify its energy data needs.

It has been very difficult to write this report to meet the policy needs of the Ministry for the Environment. Although staff of the Ministry have an increasing need for energy information their role in formulating energy policy is undefined. It seems to us that their needs for energy data depend on their policy role and it is vital that this be clarified. The Energy and Resources Division of the Ministry of Commerce is concerned mainly with short term market issues. The Ministry for the Environment surely has a role to play in ensuring that long term concerns like sustainable development and environmental externalities are taken into account.

A clarification of energy policy responsibilities should lead to the identification of data needs. This can be done by positing a series of pertinent policy questions and seeing what data are required to answer them.

Recommendation 2:

An annual volume of energy statistics should be published. Such a publication should be interpretive and user-friendly."

Energy statistics in New Zealand are in a muddle. Even within the Ministry of Commerce, one section does not appear to know what information another section has available. There is no overview of the whole energy sector and there are major imbalances and inconsistencies in data. Some information is generated to an excessive level of disaggregation. In other areas not even the most aggregated information is available. There has been little progress since the 1983 review of energy statistics.

The energy data needs of the Ministry for the Environment are not the same as those of the Ministry of Commerce. With the demise of the Energy Plan, there is no high profile single energy information publication in this country. One of the high priority recommendations of the 1983 review team was the production of an annual volume of energy and mining statistics. This would be best produced as a multi-agency enterprise probably coordinated by the Department of Statistics. Contributing institutions (private as well as public) could contribute a share of the funding, supply information, have free access to information and some say in what information is gathered.

Recommendation 3:

Most of the information in energy accounts should appear in an annual volume of energy statistics. Energy accounts would need to be supplemented by price series, international comparisons and other thriftily selected statistics of public interest.

The exercise of preparing Norwegian-style energy accounts for New Zealand has highlighted many inadequacies in the availability and presentation of energy data. These accounts could provide the major part of an energy statistics publication. Energy accounts would rectify many of the inadequacies and imbalances in New Zealand energy data.

Energy accounts:

- provide a cradle-to-grave overview of the whole energy sector;

- require regular updating;

- provide data on stocks as well as flows, on demand as well as supply;

- are balances so inconsistencies in data can be found and remedied;

- formalise links with the economy;

- provide a basis for assessing energy conservation potential; and

- provide a basis for preparing emissions accounts for energy-related pollutants.

Recommendation 4:

The Department of Statistics should give a high priority to the continuation of the Inter-Industry Studies.

Energy input output analyses of the Inter-Industry Studies are essential for the preparation of Type III accounts. These analyses have been done on the last three Inter-Industry Surveys and the time series is too valuable to discontinue. In order to support ongoing energy analyses, the coverage accorded to physical measures of energy consumption in statistical surveys should not be diminished and possibly even increased.

Recommendations that more money be spent on data collection and analysis may seem naive in the current economic climate. However, we suspect that there are sufficient funds spent in this area now and a redirection of effort and expertise would produce the recommended outputs.

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